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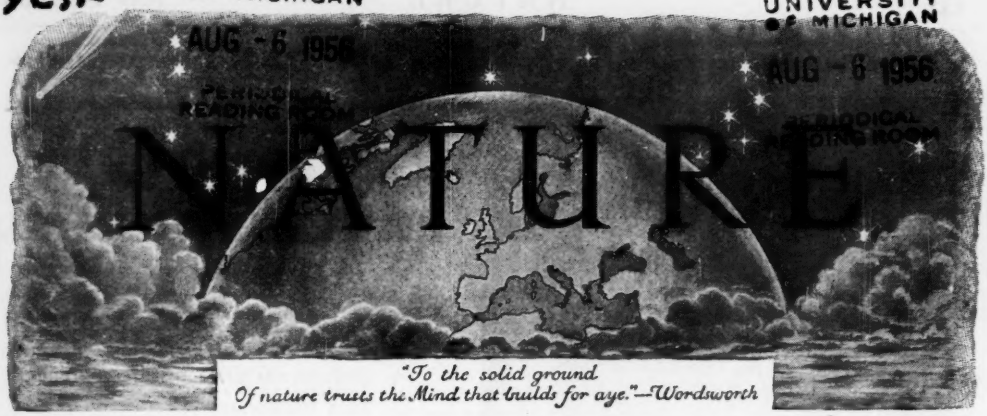

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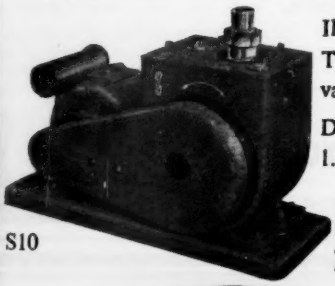

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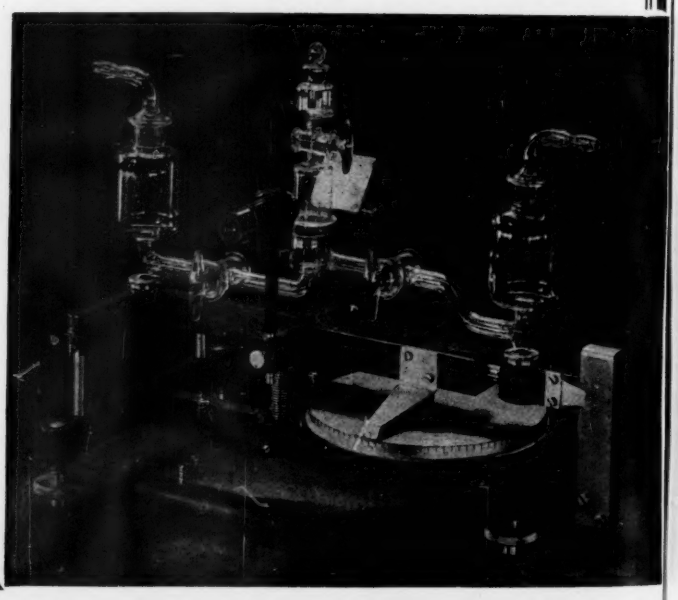

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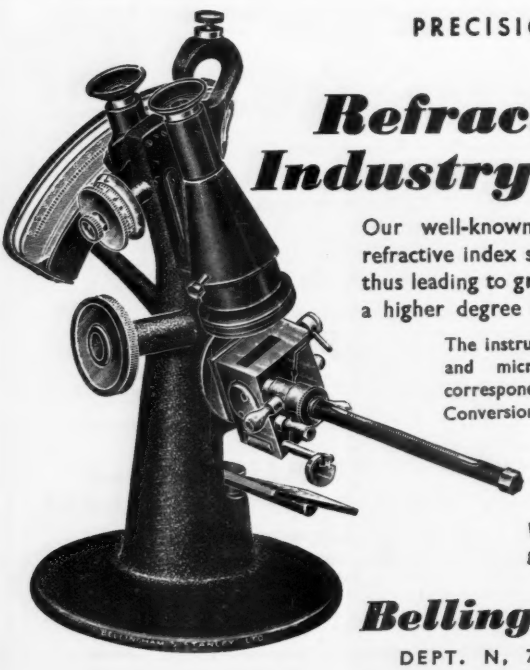

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GOVERNMENT RESEARCH IN GREAT BRITAIN

THE debate in the House of Commons on the second reading of the Department of Scientific and Industrial Research Bill on June 20 ranged over numerous aspects of the organization of research in Britain, though without pressing home the vital questions more than had been done earlier in the House of Lords. The proposal to change the Advisory Council into an executive body met with a lukewarm reception, nor was the financial clause debated at that stage. Mr. F. Willey's reference to the quinquennial principle drew from Mr. J. R. Bevins a reminder that there is an agreement about expenditure on a five-year basis between the Department and the Treasury; but there was no searching discussion of the problem of Parliamentary control in relation to the efficient conduct of research.

No more than in the House of Lords was there any serious criticism of the work of the Department of Scientific and Industrial Research, though there was some criticism of the Advisory Council for Scientific Policy, Mr. J. Callaghan suggesting that its reports were virtually ignored by the Lord President of the Council. Mr. Callaghan asked for a statement of Government policy, including a review by the Government of the organization and co-ordination of our scientific effort. He suggested also that a survey should be made of research projects, so that it would be possible to see what needs to be done but is not being undertaken either by industry, the universities or by other institutions. He also pressed once again for a Minister in the House of Commons bearing some responsibility for the scientific effort of Britain and able to deal with questions from his own experience and first-hand knowledge.

Sir Hugh Linstead supported much that Mr. Callaghan advocated, though he pointed out that finance alone will not assure effective research or provide the conditions in which research is most fruitful, and he uttered a warning both against undue Government co-ordination and excessive preoccupation in Parliament with the financial aspect, since the limiting factor in the scientific and technological spheres may well be men. Sir Hugh emphasized, moreover, that it is virtually impossible for major research to be undertaken in Britain without Government direction, and whether it liked it or not, the Government is bound to take a much closer interest in what is going on and to have an increasing say in the selection of projects and the places and the men who do the work. He appeared to look rather to the quality of the men who serve on the Council than to any formal change in organization to secure the necessary co-ordination, and he suggested that the relative distribution of the energy and resources of the Department requires reconsideration. Sir Hugh recognized, and indeed stressed, the importance of disseminating information, but suggested that forty-five per cent is too high a proportion of the Department's effort to be devoted to advisory and like services, and that the responsibility for disseminating information might well be shared with other organizations.

That is certainly a matter for examination. A large part of the value of the industrial research associations is derived from their educational influence on the industries they serve, and it would not be easy to separate sharply their advisory and educational work from research work in the usual sense of the word, whether pure or applied. The estimate of the Advisory Council quoted in the debate relates to the work of the Department as a whole: for the research associations it could well be different, and Mr. J. H. Dunning's study in the June issue of the *District Bank Review*, which was quoted in the debate, suggests that a major part of their effort, as against the 30 per cent estimated by the Advisory Council for the Department as a whole, is devoted to basic research. Moreover, as Mr. Austen Albu pointed out, in referring to the work of the Intelligence Division of the Department, which is responsible for the dissemination of the results of research, the National Reference Library of Science and Invention and the National Science Lending Library could play an important part here. The failure of the Government to take any steps to implement these recommendations of the Advisory Council on Scientific Policy or to establish the National Science Centre not only hinders the work of the Department but also tends to perpetuate existing waste and overlapping of effort. Indeed, the conversion of the former Advisory Council into an executive body, if it means anything at all, would seem to make the provision of such means for informal contact the more important if we are to avoid the rigidity of control which all participants in the debate recognized as one of the great dangers attending Government direction of research. The early establishment of a National Science Centre would contribute not merely to the more efficient dissemination of existing knowledge, but also to the establishment of the right climate for the encouragement of science and scientific research.

Mr. Herbert Morrison made no comments on this matter, but was convinced that the Lord President of the Council could make a most important contribution to the work of the Research Council, though he attached little importance to the change of function from advisory to executive. Clearly, though Mr. Morrison implied rather than stated this, the Lord President's other responsibilities should not be such as to encroach on this prime responsibility for watching over the scientific work of the Government and the research effort of the nation in general. Given the time and interest, the Lord President could, without exercising executive responsibility, do much to keep the research effort in balance, to see that projects are discontinued when no longer of real significance, and generally provide the encouragement and stimulus needed for effective research.

Mr. Morrison's experience led him to lean rather to the advisory committee system of securing expert

advice as to the selection and discontinuance of projects. Nor did he press the point about representation in the House of Commons. That was, however, put forcibly by Mr. Eric Fletcher, who, recognizing that it may not always be practicable for the Lord President to sit in the House of Commons, argued convincingly that, when this happened, some other senior Minister, such as the Lord Privy Seal, should be entrusted with the responsibility for answering for scientific matters from his own knowledge and place in the Cabinet.

The debate thus ranged far outside the work of the Department of Scientific and Industrial Research, and was indeed a discussion of the adequacy of the research effort of Britain. Misgivings were expressed as to the extent and balance of that effort; but there were few positive suggestions for improvement, though its close connexion with technological education was clearly appreciated. Sir Hugh Linstead, for example, referred to the part which the technical colleges could play in research if they received adequate grants, and suggested that this is a matter to which the new Research Council should turn its attention.

It is obvious that members of Parliament took a very wide view of the responsibilities of the new Research Council, and at times seemed to stretch them to overlap with the responsibilities of the Advisory Council for Scientific Policy. Admittedly, the Bill does not limit the responsibilities of the Research Council to the work of the Department of Scientific and Industrial Research, nor does it offer any contribution to the prevention of duplication of research effort or research grants through other Departments of State. The need persists for a closer look at the whole Government organization, for at present research grants for the universities may come through the University Grants Committee as well as the Department of Scientific and Industrial Research, research grants for the technical colleges from the latter and through the Ministry of Education, while, as the Select Committee on Estimates has stressed, research in defence departments such as the Admiralty is liable to involve risk of duplication on a large scale.

This matter of overlapping was emphasized by Mr. M. Philips Price, who, recognizing that it cannot be dealt with by the Bill and that it is not entirely a matter for the Lord President of the Council, suggested an investigation of the whole question of overlapping of research in Civil Departments, in the Service Departments and in the field of nuclear energy. This need to reduce overlapping and obsolete research was one of the main points reiterated in the debate, and two aspects of it were particularly stressed: our lack of information as to the extent of our research effort or even as to the gaps in that effort, and, less prominently, as a corollary of eliminating waste, the possibility of more co-operation and pooling of effort. The importance of a clear system of priorities was also stressed, and Mr. J. Idwal Jones also advocated more independent research institutes, besides extending research at the universities and technological and technical colleges. Apart from an indirect reference by Mr. H. Brooke, the Financial Secretary to the Treasury, in concluding the debate, to the importance of safeguarding university autonomy, however, little reference was made to the problems of financing research in universities by outside bodies which were discussed at the last Home Universities Conference.

Mr. Callaghan quoted a recent reply from the Treasury giving Government expenditure on scientific research and development as £235 million, of which only £31 million is on civil research, and he asserted that of 10,000 scientists employed by the Government about 7,500 are engaged on defence research and development. Mr. Albu estimated the total expenditure on research in Britain as about £300 million, of which between £50 million and £70 million is by industry. A recent lecture to the Institute of Physics by Sir John Cockcroft put the expenditure of industry on research for its own purposes as more than £40 million. As between fundamental research, civil applied research and defence research, he estimated that as against £200 million on defence research and more than £60 million on civil applied research, £5 million is expended on fundamental research at the universities and another £5 million in fundamental research in government and semi-government institutions, about ten per cent of the total graduates engaged on research being occupied with fundamental research.

This expenditure of rather less than five per cent of research effort of Britain on fundamental research compares with 7 per cent in the United States; and while per head of population the research and development labour force works out at about the same in the two countries, as also, allowing for differences in the value of money, do the costs of research, Mr. Dunning in his article referred to above estimates that, discounting the difference in money values, the average American firm carries out 2·5–3·5 times more research than the average United Kingdom firm. The United States are also outstripping Britain in the rate at which they are adding to their scientists and technicians, the output of graduates in engineering and applied sciences in 1954 being 136 per million of the population compared with 57 in the United Kingdom. Mr. Dunning also estimates that the parent companies of the hundred most important American subsidiaries manufacturing in Britain spend more each year, in real terms, on research and development than the whole of British industry combined, and that the size of the average parent company is five to ten times that of the subsidiary, in terms of labour force.

Such comparisons were not given undue weight in the debate in the House of Commons; they were used rather for emphasizing the relevance of technical education to the research potential of Britain. Moreover, it was also recognized that a part of the shortage of scientific man-power arises from failure to use it to the best advantage. Even if the shortage is not eliminated in this way, as Mrs. M. Jeger suggested, it would undoubtedly be alleviated by making sure that existing resources are used wisely and with the planned forethought that is appropriate for any scarce commodity. The main point is the lack of

accurate and full information on which to form sound judgments of the magnitude and disposition of the existing effort of Britain: even in regard to the alleged loss of scientific man-power overseas, information seems to be incomplete.

None the less, the absence of such information, while it restrained criticisms in the debate and particularly suggestions as to neglected fields of research, does not invalidate Mr. Dunning's broad conclusion that for sheer volume of research expenditure, and without considering the question of research efficiency, the United States command a lead over the United Kingdom which, because the results of research are cumulative, is likely to grow. The concern expressed in the debate as to the balance of research effort did not reflect any desire to curtail expenditure on fundamental research, either by the Department of Scientific and Industrial Research or at the universities, or to increase the total expenditure without due consideration of the objectives. Concern was obviously entertained as to the proportion of resources going into nuclear research. Sir John Cockcroft has estimated the number of scientists and technologists working on nuclear power as about 1,000 out of the 58,600 which Sir Harold Hartley gives as the total employed in Britain on research and development. Nor, while it was recognized as necessary that particular projects should be terminated and that research programmes should be continuously re-examined, was any real uneasiness expressed about overlapping. As Mr. Brooke remarked, a certain amount of overlapping may be fruitful: it is much more important to close any serious gaps in the advancing front of research, and we must have the knowledge that enables us to do so.

While, however, Mr. Dunning's article was quoted in the debate, his suggestions regarding co-operation in research and the pooling of results received no comment. Mr. Dunning regards the structures of the United States and the United Kingdom as complementary rather than competitive, and considers that the chief source of anxiety so far as Britain is concerned is likely to be over Continental and Asiatic competitors. To make the best use of the limited resources of Britain and so meet the demands of the future, he suggests that we should specialize in those stages of manufacturing and research to which our productive resources are comparatively the most suited, and exchange the knowledge and expertize acquired in these fields for that attained in fields to which the productive resources of the country are less well suited. Industrial development in Britain already benefits directly from the competitiveness and dynamic quality of the American system, and Mr. Dunning indicates how the gap between the discovery of a new product, process or material and its full acceptance and marketing is being bridged by the presence in Britain of firms financed from the United States.

There is an important point here bearing on the research organization and potential of Britain which was missed in the debate. If, in the way just noted, British industrial achievement is linked with an economic environment more favourable to exploitation, while the American economy benefits from the fundamental research carried out in Britain which the United States can often apply to their great advantage, we cannot be content for British firms to concentrate on fundamental research while their American associates develop and commercialize the results. Nevertheless, research co-operation in this way does offer mutual advantages in specialization, and in time the production and selling technique will be made available to British firms.

What needs to be remembered is that Britain cannot afford to rely entirely on such co-operation. There are fields in which it is vital to prosecute research independently; and in any event, undue reliance on American facilities may tend to stifle initiative and development. Co-operation will always be easiest and most fruitful when there is the right climate of opinion on both sides; and, in Mr. Dunning's opinion, while a freer exchange of knowledge between United Kingdom firms, regular visits by industrialists to the United States, and better publicity may all help, it is even more important to reconsider features of the economic and fiscal policy of Britain which tend to discourage initiative and enterprise.

That is one, but not the only, reason for taking the discussion of the Government organization of and support for research, whether fundamental or applied, out of party politics; and though this relation of research to fiscal policy was not mentioned in the debate, the discussion was refreshingly free from political partisanship. Mr. Brooke remarked in concluding the debate that we must seek a system which can preserve the freedom of the universities, the freedom of the scientist, and allow the Government to apply its resources so as to fill the gaps and stimulate the best possible work in the right directions for the whole of the industrial and scientific field. From that there would appear to have been no real dissent in the House. Only Mrs. Jeger appeared to recognize that we have still to learn much about the most economical and fruitful way of financing research in the universities, where it is now estimated that some 14 per cent of the university budget, or nearly £4·5 million in that for 1953–54, is represented by external support for research, half of which comes from the Government. Of this total, some 20 per cent of the resources of the departments of science and technology are devoted to work of direct interest to industry; and as both Dr. V. E. Cosslett and Prof. H. W. Melville pointed out at the Home Universities Conference last winter, we are only at the beginning of discussions on how best to regulate the impact on the universities of the growing interest of industrial and other external organizations in project research and to secure that there is not excessive concentration in particular fields, such as nuclear research, to the neglect of others.

The debate in the House of Commons has accordingly demonstrated the wide opportunities open to the new Research Council, although it may not have made clear how far its functions may overlap those of the Advisory Council on Scientific Policy. The Government, moreover, should have been left in no

doubt as to the urgent need to take the steps required to fill the gaps in public knowledge of the present disposition of the research effort of Britain, and particularly as regards defence research. Parliament and the scientific and technological world must be given the information essential for a sound judgment as to the way in which resources of the country are distributed in research in order to ensure that wise decisions are taken as to the gaps to be filled or the overlapping to be eliminated. Such information is essential for effective co-operation within Britain itself and also in active partnership with the United States, as Mr. Dunning suggests. The continuing debates on the Bill afford further opportunities which should be utilized to promote public understanding of what is required and to supply the goodwill and esteem which the new Research Council—and also the Advisory Council for Scientific Policy—requires to enable it to carry out its work effectively; and to ensure support for the recommendations and decisions in regard to the Department of Scientific and Industrial Research for the furtherance of research in Britain generally needed for firm action and sustained results. The debate on the second reading of the Bill at least warrants the hope that further discussions on it will proceed in an atmosphere which will facilitate and not obstruct the appointment to the new Research Council of scientists and industrialists of outstanding qualifications and abilities, and not simply representatives of particular interests.

GEOLOGICAL RECORDS OF RADIOACTIVE EVENTS

Nuclear Geology

A Symposium on Nuclear Phenomena in the Earth Sciences. Edited by H. Faul. Pp. xvii+414. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1954.) 56*s*. net.

THE new subject of radioactivity has influenced many older branches of science; but no discipline —with the obvious exceptions of physics and chemistry—was more profoundly changed by it than geology. It may suffice to recall how fundamentally its whole time-scale has been altered; when, in the second half of the past century, Lord Kelvin declared that "as an abode fitted for life" the Earth cannot have served for more than 20 to 40 million years, it was very hard for geologists to oppose him, since he was in possession of all the relevant scientific facts—except those concerning the liberation of nuclear energy. This almost unlimited source of heat was discovered only towards the end of his life through the study of radioactive elements. Now the time which the astrophysicist can grant to the geologist has been increased more than a hundredfold and, more important still, several methods based on radioactivity have been put in his hand by which he may try to determine this figure experimentally with an accuracy never hoped for previously.

It is only natural that in the present volume, with its rather unusual title of "Nuclear Geology", considerable space is devoted to these determinations of geological age; but, to do justice to the ambitious title, an attempt is made to discuss also many other geological problems which appear now in a new light after radioactive data have been applied to geology. As the book is mainly meant for geologists and not for nuclear physicists, the first chapter, on fundamental considerations, instruments, and techniques of detection and measurement, will be found useful. It is preceded by a historical introduction which enumerates the early discoveries by radioactive workers which were of importance to geologists. (It is not quite correct to say (p. 5) that the work of Richards and Lembert on the atomic weight of radiogenic lead "first *proved* the theory of radioactive decay"; besides the fact that Hönigschmid's identical work was carried out quite independently and made public at the same meeting, the considerably earlier experiment by Ramsay and Soddy on the production of helium from radium has obviously greater claim to that description.)

The introductory paragraphs are followed by chapters on the occurrence of uranium, thorium, potassium and the inert gases in Nature, on the production of heat inside the Earth by radioactive processes and the help nuclear methods may give to geophysical exploration; also the subjects of radiation damage in minerals and of the influence of radioactivity on the formation of petroleum are discussed.

The subjects mentioned cover such a wide field that the editor was well advised to enlist the help of a great number of experts (twenty-six, in fact); he was prepared to sacrifice "uniformity of view, coverage and style" in order to gain "intangible freshness and clarity which are preserved only in first-hand accounts". This is admittedly the right procedure so long as isolated chapters are concerned which can stand by themselves. However, that such divided work cannot hope to achieve everything is convincingly explained by the author of the last chapter, on the origin of the Earth. Here Prof. Harold C. Urey begins with the assertion: "It is not possible to discuss the origin of a chondritic meteorite without attempting to understand the origin of the entire solar system; in fact, the latter subject cannot be discussed separately from the problem of the evolution of stars". He deplores the fact that astronomers and physicists have attempted to explain the origin of the solar system without possessing the necessary chemical knowledge, and then presents the relevant facts about the widely varying abundances of the chemical elements. He discusses possible explanations based on the volatilities of the elements (which are known) and the temperatures prevailing at certain stages of the Earth's history (which must be conjectured); and he concludes that "much more" must be learned before a "definite and lasting model of the origin of the solar system and of the Earth is devised". It is apparently Prof. Urey's opinion that one man will have to study and digest this vast amount of facts before any effort to solve the riddles of the solar system can succeed. We may remember that, guided by a similar ideal, near the end of his life Alexander von Humboldt wrote the encyclopædic "Kosmos", and that Goethe, too, had the ambitious aim, neatly expressed by the scholar and poet Friedrich Rückert:

> Eh es sich ründet in einen Kreis,
> Ist kein Wissen vorhanden;
> Solang nicht Einer Alles weiss,
> Ist die Welt nicht verstanden.

F. A. PANETH

AMMONITES AND CHRONOLOGY OF THE JURASSIC

Jurassic Geology of the World

By Dr. W. J. Arkell. Pp. xiv+806+46 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) 105*s*. net.

THE author of "The Jurassic System in Great Britain" (1933) has capped that notable work with this equally substantial volume. Starting with Great Britain, where the succession of Jurassic formations was first determined, Dr. W. J. Arkell conducts his reader on a world tour, continent by continent, giving for each region a concise account of the rocks of this system and a critical review of the evidence as to the exact stages which they represent. Ammonite assemblages are the dominant theme throughout the work, the object of which, Dr. Arkell states, is in "no small part . . . to test the principles and performance of palæontological correlation on a world scale, to establish its capabilities and limitations". Bibliographies are given for each region, and Jurassic outcrops are indicated in numerous sketch maps. Some previously unpublished matter has been incorporated. The work is a mine of information and will be indispensable for reference.

Many will remember the controversies which, thirty years or more ago, centred around S. S. Buckman, who taught that ever-increasing precision was possible in the correlation of Jurassic rocks throughout the world on the basis of the distribution of ammonites, if only specimens were accurately collected and very critically examined. His culminating effort was to produce a scheme of about 370 'hemerae' into which, he alleged, it was practicable to divide Jurassic time. Ammonite evolution and the universal dispersal of new forms were, he maintained, so rapid that, if marine rocks deposited during any one of these hemerae were present in any region, the ammonite assemblage which then flourished everywhere would be found in them; and the absence of any such assemblage would indicate a local gap in the rock succession. A few thought that Buckman's scheme was entirely based on careful field-work (he certainly knew the Middle Jurassics of the Cotswolds thoroughly), others regarded him as a prophet who had divined the truth; but there were unbelievers who pointed out that his ideas were contrary to present-day experience of faunal provinces and the dependence of distribution on ecological factors. His doctrines were, at least, a stimulus to accurate collecting. Time has now put them to the test, and we turn with interest to Dr. Arkell's pronouncements on the subject.

That the rapidly evolving, prolific and (apparently) mostly very mobile ammonites afford the most reliable basis at present known to us for the correlation of marine Mesozoic rocks is a universally accepted fact. In the Lias, moreover, there is very little evidence of the existence of faunal provinces, the distribution of many genera being world-wide. As we ascend in the Jurassic succession, however, three faunal provinces (Tethyan, Pacific and Boreal) become distinguishable, contesting for certain regions. In the most favourable circumstances, where rocks of suitable lithology occur, a considerable degree of precision in correlation within a restricted area is possible with the aid of ammonites. Over any wide area, however, zonal schemes, much less detailed than those of Buckman, break down, and the original series of zones promulgated by Oppel in 1856–58 (amounting to about one-tenth the number of Buckman's hemerae) lies at about the limit of practical utility. Further, Dr. Arkell's considered view is that the original eleven stages into which d'Orbigny divided the Jurassic system in 1850 form "by far the best scheme yet devised for classification on a world scale". Even these are not applicable universally for the uppermost Jurassic; here we still have no means of exact correlation between d'Orbigny's Portlandian and Purbeckian in north-west Europe, the Volgian of Russia, and the Tithonian of the rest of the world. These conclusions are both a testimony to the acumen of the pioneers and a reminder that applied palæontology cannot be expected to progress on the same lines as a mathematical science. An interesting episode in the history of palæontological theory must be considered finally closed.

The concluding chapters of the work deal with other matters of general interest. Dr. Arkell is on the side of those who advocate the permanence of the main ocean basins. He has no use for palæogeographical maps, especially those showing continental masses occupying the present North Atlantic and Pacific basins in Jurassic times. Of continental drift since the Jurassic, he finds no evidence.

L. R. Cox

PROGRESS IN NUCLEAR SCIENCE

Annual Review of Nuclear Science

Vol. 5, 1955. Edited by James G. Beckerley, in association with Martin D. Kamen and Leonard I. Schiff. Pp. x+448. (Stanford, Calif.: Annual Reviews, Inc., in co-operation with the National Research Council of the National Academy of Sciences, 1955.) 7 dollars.

THIS is the fifth volume to appear in this series. The individual articles range widely from theoretical nuclear physics through nuclear engineering and radiation chemistry to radiobiology. Such publications must eschew the ephemeral progress report, the too-specialized description of experimental work or the very general treatment which properly belongs in a text-book. This volume generally avoids these hazards. The literature surveys are up to date to within about a year ago.

In a review of present knowledge of electromagnetic transitions in nuclei, Goldhaber and Weneser discuss the relative success of various nuclear models in explaining the regularities observed experimentally. Ford and Hill discuss the recent experimental information that has led to a detailed and consistent picture of the charge distribution in the nucleus. Theoretical explanations of this distribution, however, still seem inadequate. Peaslee contributes a survey of a field which has been receiving much attention recently—that of nuclear reactions in the intermediate energy-range up to 20 MeV. Here the compound nucleus model is ceasing to be applicable, and the more direct knock-on processes familiar at high energy have not yet become predominant. Two extreme models, the optical model and the statistical model, have each had some success. However, the experimental information available so far is rather incomplete.

Fretter supplies a useful article of the handbook type on the cloud chambers and bubble chambers being exploited in high-energy physics. Blizard dis-

cusses radiation shielding, a vexing technical problem for reactor or accelerator designers since the shielding represents such a large fraction of the cost. Borst compares designs of reactors intended for research purposes. Much of his discussion is of particular installations in the United States, but some of his remarks have general application. A few recent industrial problems where the mass-spectrometer has been used are reviewed by Berry and Walker.

Three articles are on radiation chemistry: a review of recent work by Dainton; a discussion of chemical effects of low-energy electrons by Krauss, Wahrhaftig and Eyring; and a useful compilation of radiochemical separation procedures by Finston and Miskel. Four articles on radiobiology complete the volume: cellular radiobiology, by Mortimer and Beam; removal of radioelements from the mammalian body, by Schubert; vertebrate radiobiology (physiology), by Edelmann; and a technical survey of radioautographic methods, by Norris and Woodruff.

The large amount of new data reviewed in these articles indicates the rapid growth and complexity of this field. The book is well produced and fully indexed.

E. B. Paul

UNIVERSITY OF SHEFFIELD

The Story of a Modern University

A History of the University of Sheffield. By Arthur W. Chapman. Pp. xvi+551+38 plates. (London: Oxford University Press, 1955.) 50*s*. net.

To the student of higher education in Great Britain the past decade has been a period of great significance, for it has seen, among other developments, the creation of four new universities. Despite the great social, economic and political changes which have followed upon two World Wars, these years resemble, at least in the creation of universities, the first decade of this century, when a number of the civic universities of Britain were founded.

In "The Story of a Modern University", Dr. Artuhr W. Chapman recounts the growth of one of these—the University of Sheffield—which received its royal charter in 1905, and which to-day has some two thousand students in six faculties. Dr. Chapman has traced, with meticulous care and skill, the development of the University and its forerunners over a period of more than three-quarters of a century. Such an achievement has required from him an intimate knowledge, not only of the University, but also of local aspirations, and those national trends which contributed to its creation, as well as an appraisal of the personalities of the stalwarts who led the movement for a university in Sheffield.

The University has indeed been fortunate in its historian, for Dr. Chapman brings to his task an unusually long and varied experience of it. He has been a member of the staff for more than thirty-five years, and has served the University with rare devotion and enthusiasm. For two decades he taught in its laboratories and lecture rooms, for almost a decade he was warden of its largest hall of residence, and for the past twelve years he has been its registrar. With this rich experience he has been able to deal sympathetically with both the academic and administrative sides of its development.

Dr. Chapman's book is, however, more than a history of a particular university. It epitomizes a movement which, during the past hundred years, has revolutionized higher education in Britain. An outstanding feature of this work is an admirable collection of pen-portraits of such leaders as Mark Firth, Henry Stephenson and W. H. Hicks, "the academic founder of the University".

This is a scholarly work, beautifully produced, with many excellent reproductions of portraits of the University's leading personalities over the years. It will be read with real pleasure and satisfaction by all who cherish and support our universities, and it might, with advantage, be read by many students to-day, who do not always appreciate the wealth of their inheritance.

Brynmor Jones

CHEMISTRY IN THE PETROLEUM INDUSTRY

The Chemistry of Petroleum Hydrocarbons

Edited by Benjamin R. Brooks, Cecil E. Boord, Stewart S. Kurtz, Jr., and Louis Schmerling. Vol. 2: Pp. vi+448. 108*s*. net. Vol. 3: Pp. vii+690. 144*s*. net. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1955.)

These two volumes now follow Vol. 1, published in 1954, and present an extensive body of information and ideas on a wide range of topics, which can more or less be included under the general title of "The Chemistry of Petroleum Hydrocarbons". The title is, in fact, interpreted liberally, and these are far from being text-books of pure chemistry. In many cases the subject-matter is treated largely from the point of view of current practice in the petroleum industry. Vol. 3, for example, begins with a short chapter on the oxidation of *ortho*xylene to phthalic anhydride. This particular section, which might well be glossed over in a text-book on chemistry, is introduced because of the uncertain supply of naphthalene in the United States and the consequent importance of this alternative route to phthalic anhydride. These two volumes are the work of forty-four contributors, and the coverage is thus comprehensive.

The specialized contributor to volumes such as these must be allowed freedom to follow his own ideas on the important current trends in his own field, since only in this way can each author contribute his detailed knowledge to the total presented. The editors of the volumes, on the other hand, must inevitably seek to achieve some unity of style and treatment, in addition to seeing that the whole field is adequately covered: they will seldom be in a position to criticize specialized detail. In the same way, the reviewer will focus his attention on the overall picture presented by these volumes, which must then be judged on the success achieved in selecting and unifying the contributions of the many authors. In justice, one might claim that multi-author volumes such as these should have multi-reviewers!

It need scarcely be said that the general presentation is excellent. Printing and paper are of high quality and printing errors are almost non-existent. There is, however, a certain unevenness in the individual chapters. Considering the form of the book in the preface, the editors conclude that "it would be necessary to limit its scope to scientific fundamentals". Many of the chapters conform to this idea. Yet the chapter on conditions and results of thermal cracking, though excellent in itself, ends with details of the design calculations illustrating

"the adaptation of an existing furnace to a Visbreaking operation". An extensive chapter on the theory and mechanism of aromatic substitution forms a splendid digest of this much-studied subject. A later chapter deals further with the theory of nitration, but surely the information that nitrobenzene is also called oil of mirbane and smells of bitter almonds could be left to the junior text-books.

The subjects dealt with in the two volumes cover a wide range. Vol. 2 deals mainly with pyrolysis (including catalytic cracking) and oxidation of hydrocarbons and includes, among others, excellent sections on pyrolytic reactions of aromatic hydrocarbons, the theory of catalytic cracking, mechanisms of the reactions of non-benzenoid hydrocarbons and the theory of hydrocarbon oxidation. In Vol. 3, the chapter on fluorination of paraffins and cycloparaffins seems rather brief, and it is surprising at first sight to see a chapter on the chemistry of natural and synthetic rubbers: this is logical, however, when the present trend towards synthetic rubber is considered. This volume includes also excellent chapters on vinyl polymerization and on catalytic hydrogenation.

These volumes can be recommended as a valuable and convenient source of information on petroleum chemistry, particularly from the industrial point of view. In addition, they include excellent survey chapters on a good deal of fundamental chemistry. If one must regret that the great bulk and pace of modern development make it difficult for any one man to collate and present the published knowledge in this field, the present editors and authors are to be congratulated on producing this much order out of the vast mass of available information.

LEIBNIZ AND NEWTON

The Leibniz–Clarke Correspondence

Together with extracts from Newton's "Principia" and "Opticks". Edited with Introduction and Notes by H. G. Alexander. (Philosophical Classics.) Pp. lvi+200. (Manchester: Manchester University Press, 1956.) 16s. net.

THE beginnings of modern science are rightly located in the seventeenth century, not only because of the positive achievements of that time, but also because it was then that the kinds of explanation which have come to be regarded as scientific were first thrashed out in philosophical discussion. Now that the broad principles of what constitutes a scientific explanation have come to be taken for granted, it is easy to forget that they emerged only after prolonged debate in which theologian, metaphysician and natural philosopher all took part, and in which indeed the major protagonists were well able to play all three parts at once. The correspondence between Leibniz and Clarke, now reprinted for the first time in English since 1738, represents the last phase of the battle. Leibniz died in 1716, only two weeks after Clarke's fifth letter had been dispatched, and no subsequent philosopher followed him in contesting the theoretical basis of science on purely metaphysical grounds.

It would be a mistake, however, to regard Clarke as the champion of enlightened science and Leibniz as the reactionary metaphysician. Much of the argument in this correspondence is of the kind that would now be called, in a pejorative sense, metaphysical, and neither Clarke nor Leibniz is concerned to make a distinction between questions of science and questions of metaphysics. With regard to theology, indeed, it is Leibniz who is the prophet of the new age, for he wishes to assert its distinction from and independence of science, but he sees this distinction as a safeguard for the doctrine of the uniqueness and transcendence of God rather than as a declaration of independence by science. This was the point upon which the controversy began. In 1715 Leibniz wrote to Caroline, then Princess of Wales, that the philosophy of Sir Isaac Newton was contributing to the decay of natural religion in England, for Newton had said that space is an organ by which God perceives things, thereby making things independent of God who created them, and also that God needs to intervene in the universe from time to time to maintain its order, like an unskilful workman who has made a machine which constantly needs repairing. This provoked Clarke to reply, as a churchman and disciple of Newton, and the correspondence continued through Princess Caroline for a year, five letters passing on either side. Its subject-matter was soon extended to include Leibniz's own metaphysical principles, and scientific topics such as the nature of space and time, the existence of vacuum, and the theory of gravitation.

On these scientific questions the argument turns upon what kind of theory is to be admitted in science, and in each case it is Leibniz who insists that theoretical explanations must conform to what he regards as self-evident metaphysical principles. There is no disagreement about the facts—Leibniz knows as well as Clarke that space void of air is produced in Torricelli's barometer and Guericke's air-pump, and that the planets move around the Sun in curved paths—it is the Newtonian explanation of these phenomena in terms of material atoms exerting forces upon each other across a void that he contests. There cannot, he says, be indistinguishable atoms because there would have been no sufficient reason for God to have arranged them in one order rather than any other, and God does not act without sufficient reason; and there cannot be a void because the universe would be imperfect if it did not contain as much matter as possible. Clarke disputes these arguments on theological grounds. He agrees with Leibniz, however, that nothing can act where it is not present, only maintaining, as Newton had done, that gravitational attraction is a fact, however it may be explained. If Leibniz can explain it by the laws of mechanism, he says, he will "have the abundant thanks of the learned world". Clarke's tendency throughout is to allow no restriction on the kind of explanation which may be given, and he is prepared to contemplate the direct action upon matter of immaterial, insensible substances as well as the direct intervention of God.

If there is any moral to be drawn, perhaps it is that science needs both Leibniz and Clarke. There is always some limitation on the kind of theory which is useful at any particular stage, and in 1716 Leibniz was right to question Clarke's immaterial substances and non-mechanical explanations. But preconceived ideas about what kinds of theory are proper can become too rigid, as physics learned again in the nineteenth century.

Mr. H. G. Alexander contributes notes and a critical introduction which contains an excellent account of the controversy on the nature of space and time as it appears in Newton, in the Correspondence, and afterwards, concluding with some remarks on the theory of relativity. MARY B. HESSE

TUBE INVESTMENTS RESEARCH LABORATORIES

NEW HIGH-ENERGY RADIATION DEPARTMENT

By Dr. A. CHARLESBY

IN recent years, interest in the civil aspects of the atomic energy programme has been mainly centred in the use of atomic energy for power production; radioisotopes produced in atomic plants have also found widespread application as tracers in industry, medicine and agriculture. A new and rapidly developing subject concerns the use of high-energy radiation to promote chemical changes, such radiation being available in atomic reactors.

Although the effects on materials of ionizing radiation in the form of alpha-, beta- and X-rays have been studied for a number of decades, the subject has received a sudden impetus in the past few years and considerable scientific and technical effort is now being devoted to it in a number of countries. This greatly increased interest arises from two main causes—the availability of powerful sources of radiation in the form of atomic piles or high-voltage generators, and the discovery of important applications of the knowledge gained from such studies. Information on the effect of atomic radiation on potential pile materials is essential in the design of high-power reactors. Moreover, recent research has shown that some of the changes induced by radiation, particularly in organic materials, may be of considerable industrial value.

The fields of potential application are extremely varied and include such diverse subjects as the sterilization of pharmaceuticals and foodstuffs, the production of mutations in plants, the initiation of chemical reactions as, for example, in the petroleum industry, and the production and modification of plastic materials. It is a measure of the rapid rate of progress in this field that although some of the basic discoveries were published only a few years ago, processes based on these have already reached the industrial stage. The field of application will undoubtedly extend with further research. Eventually, high-energy radiation may indeed supersede certain chemical treatments involving heat or chemical reagents. It has already been found that some processes which cannot at present be carried out by conventional chemical techniques become feasible by the use of high-energy radiation which can be applied in solids, liquids or gases at any desirable temperature.

Although the development of the subject is closely bound up with atomic energy, it should perhaps be emphasized that this relationship is largely of a historical character. The observed changes in physical and chemical properties arise from disturbances in the electronic structure and not from any changes in the nucleus. Of the sources available to produce such modifications, only a certain number rely directly or indirectly on nuclear transformations. These include the atomic pile itself, radioactive uranium rods withdrawn from atomic piles after use, or fission products which would otherwise be wasted. Naturally occurring radioactive elements or radioactive isotopes produced in the pile, such as cobalt or cæsium, may also be used for producing the required radiations. Chemical changes may be caused by alpha-, beta- or gamma-rays produced by such sources, either alone or together with the slow and fast neutrons present in atomic piles.

For most applications of radiation, beta- and gamma-rays appear to be most useful and convenient. Alternative sources of radiation are, however, available which do not rely in any way on nuclear changes, but instead depend on electrical high-voltage equipment, including linear accelerators, Van de Graaff machines, cyclotrons and X-ray equipment. It has been found that many of the effects obtained depend only on the energy absorbed within the material being irradiated and not on the type of radiation or its energy, which determines the penetration within the specimen. Thus, results obtained under certain experimental procedures can often be readily translated into those for very different radiation conditions. Experiments carried out with low-intensity fission products can be used for determining the feasibility of using radiations from high-power accelerators and, conversely, information obtained from the use of such accelerators can eventually be applied when fission products of high intensity become available with the growth of the atomic energy programme.

Until recently, work on the changes which can be produced by radiation have been largely confined to the use of low-intensity sources in universities and atomic energy laboratories; but the stage has now been reached where British industry is entering into the field. The equipment installed at the Tube Investments Research Laboratories, Hinxton Hall, Cambridge, is the first industrial installation designed specifically to pursue this work on a larger scale and with a greater degree of control of radiation conditions. To permit treatment with various types of radiation of different penetration and ionizing power, a number of radiation sources are available; these comprise a high-voltage accelerator giving 2 million volts, several X-ray machines and a large radioactive cobalt source.

The radiation building has been designed primarily to provide accommodation for the radiation sources and operating personnel; the preparation of specimens and the subsequent studying of the changes produced will normally be carried out in a separate laboratory building now under construction. The radiation building itself comprises a tower flanked by two small wings, one of which houses the smaller sources and the control gear for the main 2-million volt accelerator. This is installed in the upper of the two stories of the central tower and projects vertically downwards into the radiation treatment room on the lower story. The second wing of the building is used at present as a test laboratory, but is arranged for conversion to accommodate longer specimens which can be fed from one wing to the other through the radiation chamber. To protect personnel in the two wings against the intense radiation present in the radiation chamber, the walls consist of 3 ft. of concrete, while the heavy steel door is lined with lead. The radiation-level in the control room is constantly monitored and recorded. Specimens are

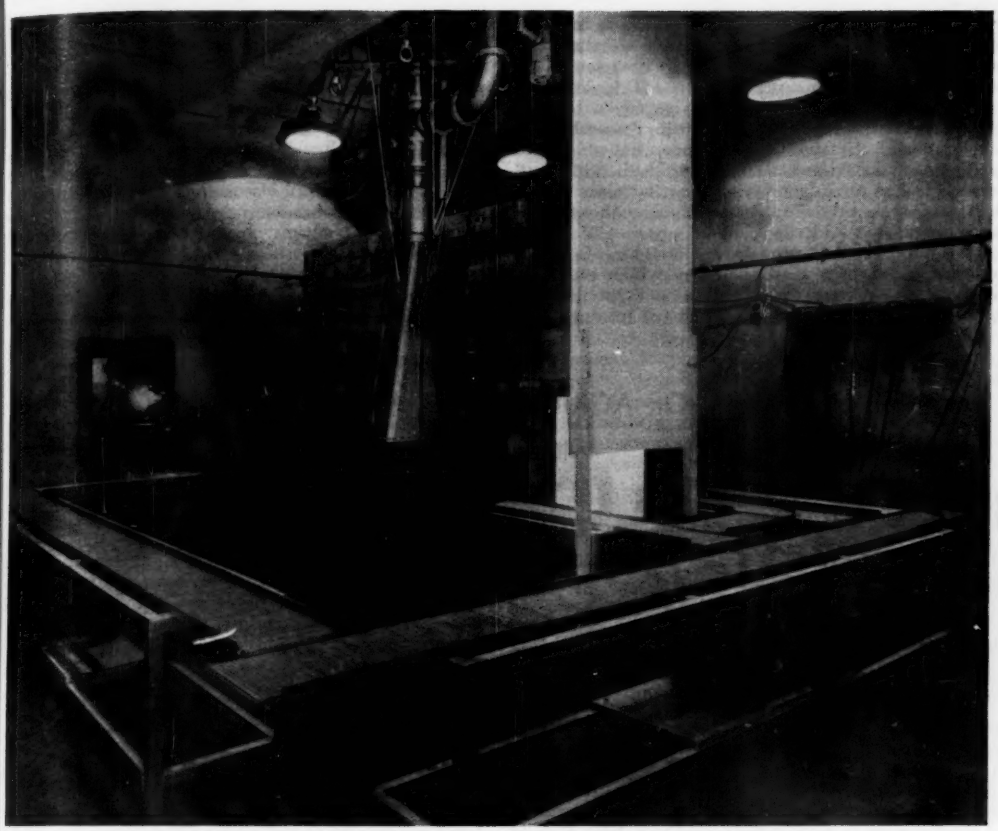


Fig. 1. General layout of the conveyor system within the irradiation chamber. The output tube for 2-MeV. electrons, showing the electromagnetic beam scanner, Faraday cage and viewing window, can also be seen

ed into the radiation chamber by a conveyor system passing through a labyrinth. A glass viewing-window approximately 1 ft. across allows specimens to be observed during treatment. This window consists of forty-one sheets of $\frac{3}{4}$-in. glass separated by medicinal paraffin oil to prevent multiple reflexions which would otherwise make direct vision impossible. A separate chamber houses the necessary ventilation and heating equipment.

The Van de Graaff electro-static generator supplied by the High Voltage Corporation, of Cambridge, Mass., is capable of producing an electron or ion beam of 2 million volts and of high intensity. By operating under a gas pressure of some thirty atmospheres, the total size of the installation has been considerably reduced. Under normal operation, it can generate 500 watts of electron-beam power, equivalent to the total radiation power available from many tens of thousands of curies of radioactive cobalt. By using an electron beam, the equivalent radiation intensity is even greater, since substantially all the energy emitted can be directed on to and absorbed within the specimen. Although most efficiently used for electrons, the generator can be converted to produce gamma radiation, fast protons or neutron radiation should these be required for special purposes.

Articles for radiation can either be placed immediately under the beam or fed from the control room by means of a flexible system of conveyor belts. The electron beam is scanned across each specimen by electromagnetic means controlled externally by the operator. The speed of the conveyor belt under the beam can also be varied over a wide range, and reversing mechanisms are available in the control room to enable specimens to be passed back and forth across the beam. Thus, a very wide range of radiation conditions can be readily obtained. After radiation, specimens may be taken out of the radiation chamber on the conveyor system and can then be handled immediately, since no induced radioactivity is produced with electron beams or gamma radiation of this energy-level.

In addition to the high-voltage accelerator, an X-ray machine operating at about 200,000 volts is available; this produces a radiation flux of higher penetration than from the 2-million volt electron beam, but the intensity is much lower. A second X-ray machine produces an intense beam of X-rays of up to 50,000 volts. Penetration of this radiation is very low and the equipment is mainly intended for surface treatment.

A high-intensity radioactive cobalt source gives highly penetrating gamma radiation of 1·3 million volts. This equipment has been designed to allow specimens to be irradiated at varying dosage-rates and at different temperatures. During the loading process, the cobalt source sinks into the base. To

protect personnel during this operation, a number of interlocking devices are incorporated so that the container cannot be opened until the source is retracted into the safe position.

The programme of work envisaged with the radiation equipment includes both research and development. In the first instance, the effects of irradiating plastic materials are being studied in detail because it has already been shown that very useful changes can be produced in materials such as polyethylene, rubber and silicones.

At the same time, fundamental research is being undertaken into the mechanism by which radiation interacts with matter, and includes such problems as the irradiation of solutions, effects of inhibitors or protective agents, and the dependence on temperature of radiation-induced chemical changes. The investigation of radiation effects in materials may be considered as a new branch of scientific study involving close collaboration between chemists, physicists and biologists. Many of the effects observed are very novel, and their elucidation should provide not only a basis for further advances in radiation techniques and applications but also may well throw light on basic chemical reactions. The number of problems open for investigation is embarrassingly large, and collaboration with other organizations and research associations interested in the study or application of radiation methods is essential if rapid advances are to be made in this exciting new field.

THE MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

WILSON REPORT

IN December 1954 an independent Committee, that is, not an inter-departmental one, was set up to review the ex-Headquarters organization of the Ministry of Agriculture and Fisheries, to which has now been added the remnants of the Ministry of Food, making it the M.A.F.F. The report of this Committee has recently been published* and, from the name of its chairman, Sir Ayrton Wilson, is being referred to as the Wilson Report. Anyone desirous of forming a clear view of the multitudinous activities of this Ministry and how they impinge on the farmer cannot do better than read this report. Although conforming to the usual style of such reports, with short numbered paragraphs, it is extremely lucid and readable and displays throughout its hundred pages the extreme thoroughness with which the members of the Committee have carried out their difficult task.

The Committee was asked "to consider generally whether the organization is best adapted to secure efficient and economical performance of the functions of the Ministry", to which the Committee's reply is summarized as, "It could certainly be better adapted"; whether "there was undue complexity, over-specialization, or overlapping", to which the reply is, "Yes! there is"; and whether "there was duplication and unnecessary interference with the work of local authorities", to which the reply is, "Little or no evidence of this". In addition to these three questions, the Committee was asked to survey the remaining organizations of the Ministry of Food and also to examine carefully the methods for dealing with the acquisition, management and disposal of land by the Minister and with the preparation of cases for consideration under the Agricultural Act of 1947 and the Agricultural Holdings Act of 1948. Because these cases impinge so directly on the rights and livelihood of individual citizens, the Minister evidently felt it necessary, in view of public criticism, to have existing procedures reviewed by an independent body. Comparatively minor improvements are put forward.

The report concludes with no less than seventy-eight main recommendations which, if put into effect, would result in savings approaching a thousand in staff and £1,000,000 in salaries, travelling expenses and general overheads. There would be additiona savings on premises difficult to estimate accurately in advance. With the present Government committed to some reduction in national expenditure, it is evident that many of the recommendations of the Wilson Committee are likely to be implemented and they are now being considered by the County Agricultural Executive Committees as well as by the organizations concerned. Clearly it is not possible here to give an adequate summary of the voluminous report and its many findings; but an attempt will be made to select some of the major points.

Apart from its headquarters staff, the Ministry has no less than thirty-two organizations which can be divided into six major groups, with a staff of 8,500, and twenty-six smaller groups with about 1,500. The total annual cost is just under £10 million. The major groups are the County Agricultural Executive Committees, the National Agricultural Advisory Service, the Agricultural Land Service, the State Veterinary Service, Fatstock-Marketing, and the National Milk Testing Service. Examples of the minor groups are the Agricultural Lime Department, Land Drainage and Water Supply, the Rodent Inspectorate and the Insect Inspectorate. The organizations work within twenty-two different sets of boundaries—a fact which, in itself, indicates the probability of frequent lack of co-ordination.

Before planning some pruning, streamlining and regrouping of these numerous bodies the Committee first pointed to certain weaknesses, abnormalities and dangerous tendencies, and then laid down some desirable principles. Unlike most government departments, the Ministry of Agriculture and Fisheries has created its own local authority in the form of the County Agricultural Executive Committees and invested them with both advisory and executive duties. For the executive work, the Ministry has made much use of technical and professional staff instead of keeping to the usual practice of using administrative staff. The numerous separate organizations had the dangerous tendency of getting away from team-work altogether. "The Ministry's local organization is riddled with divided loyalties and dual control." The basic principles which, in the opinion of the Committee, ought to be followed are: first, the operations and methods of a Ministry should be supported by a broad body of public

* Report of the Committee appointed to review the Provincial and Local Organization and Procedures of the Ministry of Agriculture, Fisheries and Food. Pp. vi+108. (Cmd. 9732.) (London: H.M. Stationery Office, 1956.) 4s. 6d. net.

consent; second, that clear ("clean" is printed in the report) lines of command should flow from the centre to the farthest out-station, leaving no officer in doubt about his responsibilities or about who is his superior officer; third, the insidious growth of "perfectionism" must be avoided, for example, the tendency to develop a function beyond reasonable limits and regardless of cost; fourth, the organization and procedure must permit effective control of finance —not merely precise audit but provision for thorough preview of proposed outlay.

The most important local body is the County Agricultural Executive Committee, particularly as the National Agricultural Advisory Service county staff is closely associated with it. The proposals of the Wilson Committee regarding the County Agricultural Executive Committees can be taken as illustrative of the lines along which reorganization is envisaged. At the time of the Ryan Committee set up in 1949 with somewhat similar terms of reference, four of the main jobs of the County Agricultural Executive Committees were their responsibility for production targets, conduct of the Farm Survey, supervision of backward farmers, administration of trading services and subsidies. Since then, however, targets have gone, the survey has practically ceased, supervision cases are trivial in number; on the other hand, the country has continued to pay large sums in grants and subsidies. It is clear, therefore, that there must now be concentration on technical development to ensure higher and higher efficiency if the subsidies are to be justified. Technical development must in future be the first and primary duty of the County Agricultural Executive Committees, working in close co-operation with the National Agricultural Advisory Service. A second function would be to act as local adviser to the Minister.

Where State action affects the liberty and livelihood of the individual farmer, there is also need for local consideration of appeals against decisions of Civil servants dealing with routine work such as grants and subsidies. Other local problems, such as the completion of rabbit clearance and the use of land for particular purposes, can be dealt with by the same body. The Wilson Committee accordingly recommends that the future structure of a County Agricultural Executive Committee should be a Main Committee to concentrate on technical work and advice to the Minister, but delegating the other functions mentioned to a tributary body called the Executive Panel. The delegation of duties should be complete, the Main Committee merely receiving a regular report from the Panel. The word 'Executive' would in future be omitted from the name of the County Committee so that it would become the County Agricultural Committee. The chairmen of these Committees, preferably younger men than at present and with a broad outlook and constructive ideas, would meet regularly in the different regions and also have close links with the Minister through liaison officers. With a few exceptions, such as East and West Suffolk which would probably be made into one unit, the County Agricultural Committees would remain on the present county basis.

The report next deals with the routine executive and trading work no longer to be done by the County Agricultural Committee. For these the unit of area suggested is again the administrative county, except that there would be more amalgamations of smaller counties, for example, combining Cumberland with Westmorland, and Bedfordshire with Hertfordshire. In this way the existing sixty county units would be reduced to not more than forty, each with its "Divisional Executive Office". Besides doing the routine work mentioned, the Divisional Executive Office would provide clerical staff for the County Agricultural Committee and have attached to it the Area Milk Organization, the Lime Inspectorate, Pest Officers, etc. The office would be under the control of a senior member of the Civil Service Executive Class. The executive divisions (= counties or amalgamated small counties) would be grouped into Regions with boundaries, for the most part, coinciding with the present Standard Government Regions. In the north and in the south-east, combinations of two regions would reduce the ten Government Regions to eight Agricultural Regions. Wherever possible, the Ministry's Regional Staff would be centred in the standard regional "capital", such as Cambridge. Here there would be in command an administrative, not a technical, officer with the rank of Assistant Secretary. He would be the Ministry's chief official and representative in the region, and would supervise all regional staff comprising twelve separate services such as the National Agricultural Advisory Service, Fatstock Marketing, Defence. The technical staff at regional level, though under the general direction of the Controller, would retain the right of direct access to their superiors at the Ministry on technical matters.

Regarding the twelve services at the regional centre (four of them at county-level also), numerous recommendations are made, some of considerable importance. The National Agricultural Advisory Service would have lost most of, but not quite all, its non-advisory functions. It is also proposed that it should hand over to the Veterinary Service its Milk Production Officers who, "for all practical purposes are not advisory officers nor does the present nature of their work require them to be milk production specialists—they are scarcely concerned until the milk is in the pail". The number of Farm Machinery Specialists is also thought excessive and it is recommended that there should be one at each regional centre and one in large arable counties. In the case of horticulture, the recommendation is that the regional specialists should be reduced in number and sent to front-line work in the counties, where they should be able to do more effective advisory work. The Wilson Committee very pertinently and rightly directs attention to an outstanding weakness of the National Agricultural Advisory Service's structure (which some, including the present writer, pointed out even before it had started to function), that the 'key' man of the service, the District Officer, could only get promotion by "being withdrawn from front line work". An important addition to the Service is recommended owing to the proposed reorganization of the present Agricultural Land Service: it is that a specialist estate management section should be formed at regional level. The land service, it is suggested, should shed its extraneous non-professional duties and become a compact body of highly qualified land agents. Its local organization would be based on the new divisions and obtain its clerical staffs and common services from the Divisional Executive Offices. A somewhat similar reorganization is proposed for the Veterinary Services.

A long chapter of the report deals with "Milk Administration". "We have found it fascinating but extremely complicated." The main recommendation

is that the National Milk Testing Service with its 350 staff should be disbanded and its work handed over to the Milk Marketing Board and the Veterinary Inspectorate. It was always difficult to see any real justification for the existence of the National Milk Testing Service.

In conclusion, one feature of the reorganization planned by the Wilson Committee may be pointed out which will please those who, like the writer, continue to maintain that the advisory and educational services should never have been divorced and should be 'remarried' as soon as possible. The County Agricultural Committees will remain based, in general, on existing counties and will have, as their chief concern, technical development and advisory work. It would be a small and comparatively easy step to add to these duties the responsibility for agricultural education in the counties. A great accession of strength would accrue to both services and further large economies in man-power and expenditure could be achieved together with greatly increased efficiency.

H. W. Gardner

STRUCTURE OF VITAMIN B_{12}

By Dr. DOROTHY CROWFOOT HODGKIN, F.R.S., JENNIFER KAMPER, MAUREEN MACKAY and JENNY PICKWORTH

Oxford

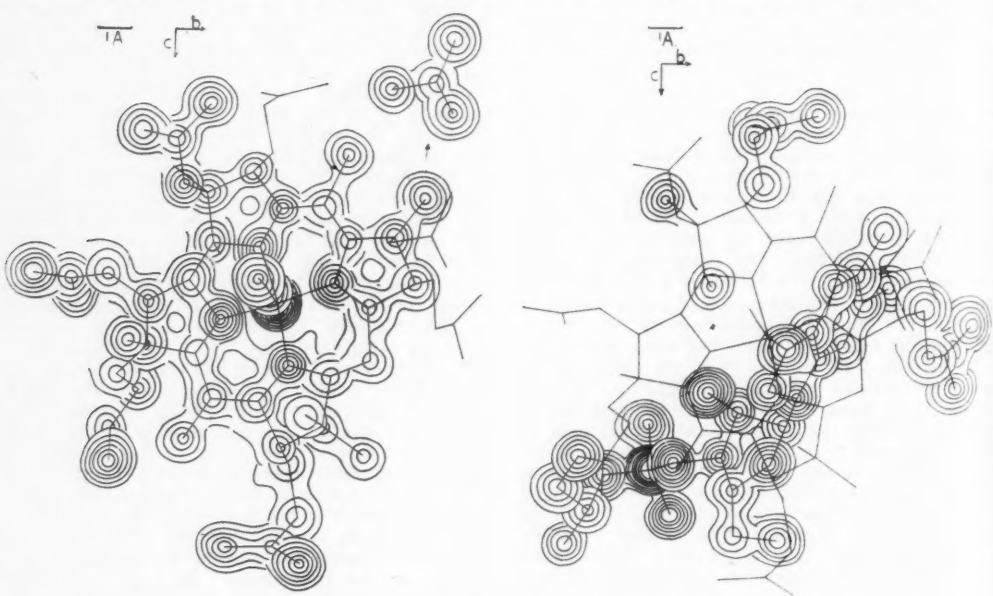
KENNETH N. TRUEBLOOD
Los Angeles

AND

JOHN G. WHITE
Princeton

SINCE our communication in August 1955[1], we have carried our refinement of the structure of vitamin B_{12} a critical stage further. Four more calculations of the electron density distribution have been made, one for the wet B_{12} crystals, two for air-dried B_{12} crystals and one for the hexacarboxylic acid.

In Fig. 1 are shown the electron density peaks over all the atoms of the B_{12} molecule as it appears from our present calculations in the wet crystals. These peaks are rather lower than those observed for the hexacarboxylic acid owing to the smaller number of X-ray reflexions given by the larger molecule in proportion to its size. But they serve to show the relative positions of all the atoms in space of this very complex molecule within probably as little as 0·3 A. Similar evidence has been obtained for air-dried B_{12}; for both crystals the reliability indices in the latest structure factor calculations, 36·1 and 30·6 per cent, respectively, are now low



(a) (b)

Fig. 1. Electron density-levels from the three-dimensional electron density distribution for wet B_{12} crystals, calculated with terms phased on 93 atoms

Here, and in Fig. 4, the contours are drawn in the sections of the calculated distribution parallel with the *a* plane, passing at or near the atomic positions. Owing to the complexity of the molecule, complete contours for every atom are not given and the figure is divided into two parts. (*a*) shows the cobalt-containing nucleus and cyanide group; (*b*) the benziminazole, sugar, phosphate and propanolamine groups, the side chains being divided between the two. The acetamide chain on ring *B* is inset. The contour interval is 1 $e/A.^3$

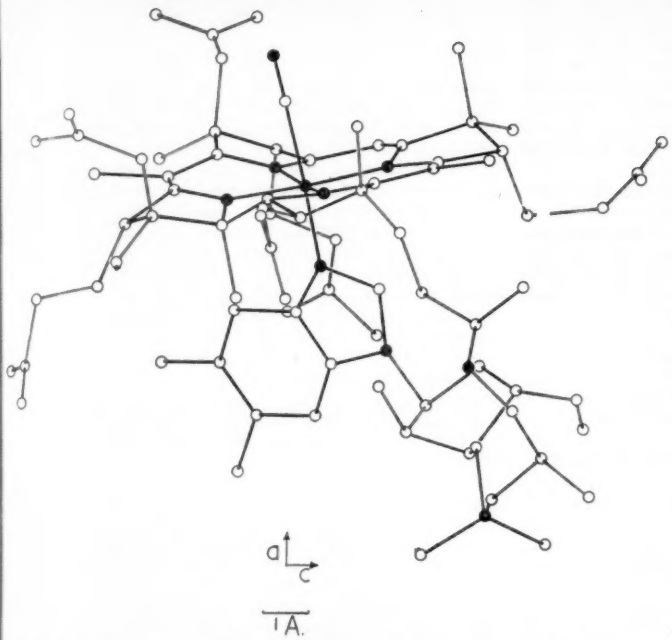
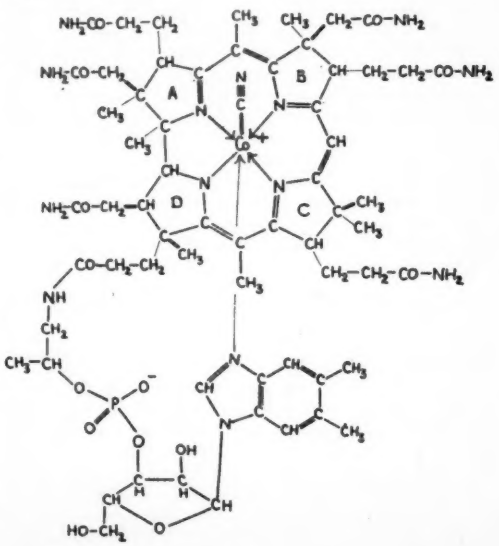


Fig. 2. The atomic positions found in the molecule of vitamin B_{12}. These are shown as derived in the wet crystals, projected on the *b* plane. To distinguish different parts of the molecule, bonds within the cobalt containing nucleus, benziminazole and cyanide groups are shown in black, together with the cobalt and phosphorus atoms and the nitrogen atoms of the nucleus, benziminazole, propanolamine and cyanide groups

enough to indicate that the solution we have reached is likely to be essentially correct.

The molecule that appears is very beautifully composed, not far from spherical in form, with all the more chemically reactive groups on its surface. It is drawn in projection in Fig. 2. It is built around the two planes of the benziminazole nucleus and the central cobalt-containing nucleus, which are nearly at right angles to each other. The ribose ring turns in a position nearly normal to the benziminazole group, which permits its easy linking through the phosphate, propanolamine, and propionic acid residues to ring *D* of the planar group. The benziminazole nucleus is packed in on either side by the propionamide side-chains in the extended, staggered configuration, attached to rings *A* and *B*; the side-chain on ring *C*, in the gauche configuration, lies above the ribose ring. All the acetamide residues project from the opposite side of the nucleus to the propionamide residues, towards the cyanide group. It is an interesting point that one of them—that on ring *B*—swings round the carbon–carbon single bond from a position directed away from, to one in contact with, the cyanide group, when the crystals are removed from their mother liquor; this permits the rather closer packing of the molecules found in the air-dried crystals. Throughout the molecule, as shown by Figs. 1 and 2, the atomic positions found conform in a most convincing way with the stereochemical rules established by the study of simpler molecules.

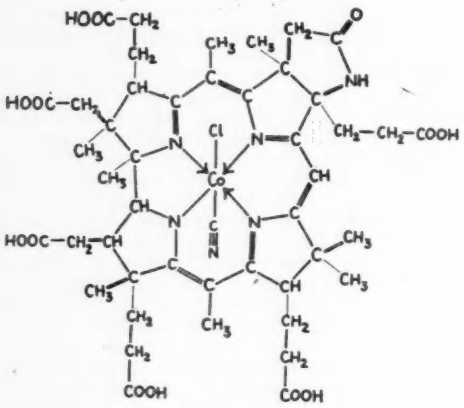
It now seems reasonably certain that we should formulate vitamin B_{12}, $C_{63}H_{88}O_{14}N_{14}PCo$, as in I, and the hexacarboxylic acid as in II, with six double bonds in the inner ring of the central nucleus; these can form a resonating system by intervention of the cobalt atom as illustrated by III. Some evidence in support of this has been obtained by theoretical calculations[2], by spectroscopic measurements[3] and from further chemical studies[4]. Our own evidence for this formulation is the geometrical form of the nucleus, which is illustrated by Fig. 3, and which is closely similar in all three crystals studied. The interatomic distances shown in this figure are derived from the latest calculations on the hexacarboxylic acid and are not individually very precise; in other parts of the molecule distances differing by as much as 0·16 A. from accepted bond-lengths have been found. But it is notable that in the region N_8–N_{18} *all* the bond-lengths are shorter than normal single bond distances; their average value, 1·36 A., is similar to that found in the phthalocyanines[5]. The positions of C_{29} and C_{30}, one or other of which would be expected to be out of the plane of the central ring system if only five double bonds were present, are even more significant. In the hexacarboxylic acid they appeared at all stages of the refinement to be within 0·2 A. of this plane, but in the B_{12} crystals themselves their positions were at first more confused, particularly C_{29}. As a critical test, accordingly, this atom was omitted from the phasing calculations used for the latest electron distribution calculated for air-dried B_{12}. It has now appeared, as Fig. 4 shows, as a small but clearly defined peak at a site which is closely equivalent to that found in the hexacarboxylic



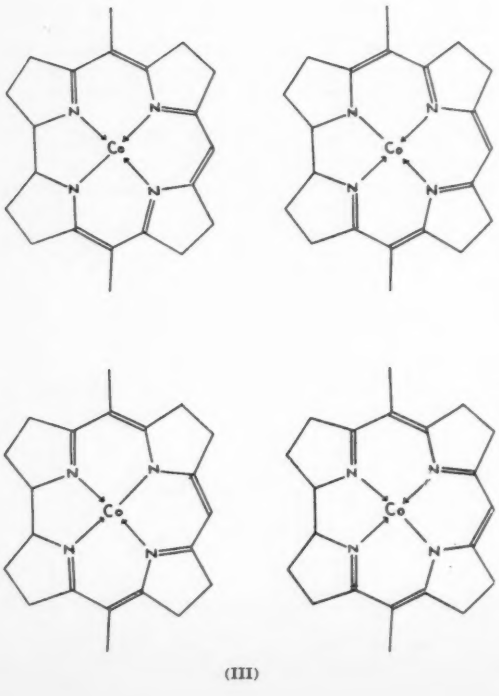
(I)

acid along the line Co to C_8. There is still some departure from planar character in this region of the inner nucleus in both wet and air-dried crystals, but this seems to affect N_{16}, C_9 and C_8 as much as C_{39}. If real, it may be a consequence of a small amount of compression from the benziminazole nucleus, which is in contact with these atoms. It is, in any event, not of the geometrical form that would be expected if C_8 were reduced.

The crystal structures of the different B_{12} compounds are still not completely solved; many of the water molecules which occupy space between the vitamin molecules have been placed, but not all. Still further small adjustments are to be expected on continued refinement of the atomic positions



(II)



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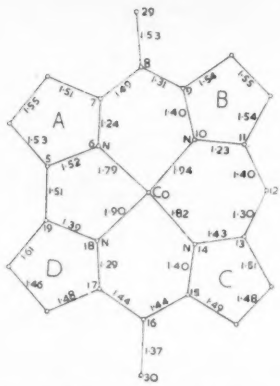

Fig. 3. Interatomic distances found in the inner nucleus of the hexacarboxylic acid, derived from nine refinements of the calculated electron density distribution

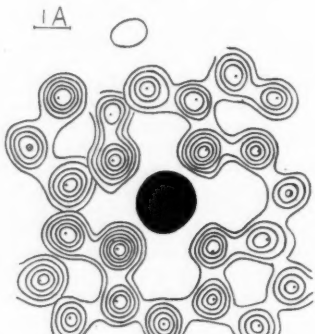

Fig. 4. Electron density peaks over the nucleus in air-dried vitamin B_{12}, derived from the three-dimensional electron density distribution calculated with terms phased on 95 atoms (Princeton data)

observed. We hope that future calculations will add still greater precision and certainty to our knowledge of the structure of the molecule.

The latest series of calculations on wet B_{12} were carried out on the University of Manchester electronic computer through the generous co-operation of Dr. D. W. J. Cruickshank, Miss Diana Pilling and Mr. J. F. P. Donavan, of the University of Leeds. Those on air-dried B_{12} and on the hexacarboxylic acid were made on the National Bureau of Standards automatic computer in Los Angeles, supported by the United States Office of Naval Research.

Again we acknowledge the very generous support given this research by the Nuffield Foundation, and materials and help given us by Dr. E. Lester Smith, Glaxo Laboratories, Ltd., and Dr. K. Folkers, Merck Laboratories. Two of us (J. P. and J. K.) received grants from the Department of Scientific and Industrial Research.

[1] *Nature*, **176**, 325 (1955).
[2] Orgel, L. E. (private communication).
[3] Beaven, G. H., and Johnson, E. A., *Nature*, **176**, 1264 (1955).
[4] Todd, A. R. (private communication).
[5] Robertson, J. M., *J. Chem. Soc.*, 1195 (1936). Robertson, J. M., and Woodward, I., *ibid.*, 219 (1937).

OBITUARIES

Prof. George Sarton

It has been my privilege to enjoy the friendship of George Sarton for forty-three years. He was, in my judgment, one of the great teachers of our age. This was not because he was in the ordinary sense eminent in science, nor because he was an acute investigator, nor on account of anything startlingly original in his outlook. It was because he was a superb organizer of knowledge and an unrivalled integrator, and because these powers came to him with an extraordinary devotion to learning, a uniquely clear vision of its object, an Olympian firmness of purpose, and a quite exceptional industry and linguistic equipment. For about the last twenty years of his life, he was one of the most widely learned scholars in the world. Though he long held a post as historian of science at the Carnegie Institution and a chair of the history of science at Harvard University for many years and was a good, clear, allusive lecturer, he was not a great academic success in the sense of attracting a large following of students. He was, nevertheless, one of the most important intellectual influences of our time, for he defined, illustrated and developed as a new discipline the study of the history, principles and method of science. This he called 'The New Humanism'. The title is not ideal, but it denotes an approach that bids fair, in the New World at least, largely to displace the old humanism.

Apart from the width and depth of his learning, his literary output was very impressive both for its bulk and quality. He edited and largely contributed to fifty-five solid volumes of the journals that he founded—*Isis* and *Osiris*. Many of these volumes contain an introduction by himself which I am tempted to call a sermon. These provide a body of moral and scientific philosophy. It would be worth while putting together the best of them, for they would form a good guide to anyone proposing to devote his life to scientific research. No one can write on ancient or medieval science without often consulting the five enormous volumes of Sarton's monumental and mistitled "Introduction to the History of Science". Its title is wrong because it has become more a court of appeal than an introduction and is seldom consulted in vain. He was the author of many other works, but his great "History of Science", which was to be the crown of his old age, is alas! a torso. He produced the first volume, which is on the science of the Ancient Empires—not the period on which he was strongest—and the second volume is in the press. The remaining half-dozen will never see the light.

Sarton was a very human figure with a Gallic wit, a not unpleasant sense of his own greatness, and a few foibles. Among the latter was an odd aversion to Plato and an incapacity—which grew on him with the years—for writing without adding notes to his text. Even his reviews had notes, and even notes to the notes. But he was always a good, clear and simple writer and one may search many pages of his innumerable works without finding an obscure passage.

His linguistic attainments were astonishing. He was brought up trilingual—French, Flemish and German. He had a good classical education and graduated in the physical and mathematical sciences in his native Belgium. He married an English lady in 1912 and before settling in the United States acquired fluent and perfect English which was, however, never quite freed from a delightful Gallic tang. He could use all the major European languages freely and obtained facility in Hebrew and Arabic. He knew some Chinese and was led to its study by something more than an inkling of the great technological and scientific treasures in that language that are now being unearthed by Dr. Joseph Needham. To all the vast stores of learning that these accomplishments imply, he added a very wide knowledge of modern science. In his later years he had become particularly attracted by biology and, though without early training in that department, it is remarkable how much he wrote on it and how seldom he stumbled for lack of understanding. He was a master of those who know, and it is therefore not entirely fanciful to compare him to his own master, Aristotle.

What influence did Sarton exert on our age? I can only put the matter as it appears to me. Among 'humanists' surprisingly little, and in Great Britain scarcely any at all. By most English students of the classical, literary and historical disciplines in Britain his massive works are, I imagine, scarcely ever consulted and remain almost unknown. In the United States he had become something of a national figure, and there, even among humanists, his influence was certainly greater. This partial eclipse of his genius is, I believe, temporary. On both sides of the Atlantic the overwhelming need for scientific and technological training and the corresponding earlier specialization is producing a novel situation. A new humanism is needed, and several universities in England and a larger number in the United States have instituted departments of the philosophy and history of science. In these the work of Sarton is given a place accorded to that of no other man, and his influence in all that concerns the humanization of science is bound to increase in the near future.

Lastly, what were the intellectual influences that were instrumental in moulding Sarton's own thought? There can be no doubt that, of those who lived into the twentieth century, Tannery and Duhem affected him most deeply. More distantly he was evidently a follower of August Comte, and his greatest works bear the authentic Comtian mould. He accomplished the task which Comte suggested. The key to Sarton's thought is that true knowledge is a unity and that to divide it into categories—scientific, literary, religious, æsthetic, etc.—for any but practical purposes, is to mistake its nature.

All his work was helped by a serenely happy domestic life. Sarton died in April of this year at the age of seventy-two. Mrs. Sarton—who was an artist in her own right—died some years ago. He is survived by a daughter, May Sarton, a distinguished novelist and poet.

CHARLES SINGER

Dr. G. Liebmann

GERHARD LIEBMANN, who died suddenly on June 18, was born on June 29, 1906, in Berlin. In 1925, he matriculated at the Falk Realgymnasium, Berlin, and proceeded to read physics in the University of Berlin under such teachers as Planck, Von Laue, Schrödinger, Wehnelt and Nernst. He graduated with honours in 1928. Continuing as a postgraduate research student, he was awarded his doctorate of philosophy in 1930. Following this, he was awarded a German national research fellowship

in physics which he served under Prof. Nernst, at the same time assisting Prof. Wehnelt as demonstrator. After six further years research in German industrial laboratories, he came to Britain because of the adverse conditions in Germany under the Nazis in 1936. Shortly after his arrival in Britain, he was appointed chief physicist and head of the Vacuum Physics Section of Cathodeon, Ltd., in Cambridge, where he served until 1947, when he took a senior appointment in the Research Laboratory of the Associated Electrical Industries, Ltd., at Aldermaston in Berkshire.

His earlier researches in Germany were concerned with high-temperature physics, infra-red spectra and electronic valves. In Great Britain, he made important contributions in the development of television cathode-ray tubes, valves and image converters. He became interested in the electron microscope while in Cambridge, and built an instrument there.

Already he had published many papers, and taken out more than forty patents. He later developed his interest in the electron microscope, and put to good use his innate mathematical ability and ingenuity. His development of the resistance-network analogue calculating method, and his use of this in calculating the properties of electron lenses, contributed largely towards the development of greatly improved electron microscopes. His scientific papers were then appearing in many scientific journals, and were being read in European countries, in the United States and in Britain. He latterly extended his reputation in the computational field by the development of resistance-network analogue methods for the solution of the transient heat flow equations, fourth-order differential equations, and the more complicated equations occurring in thermal stress and neutron diffusion problems. He lectured by invitation in the United States in 1955, and in Brussels early in 1956, and was appointed vice-chairman of the International Analogue Computation Association. He had long been a Fellow of the Institute of Physics, and several times lectured at the Institute, and was a member of the American Institute of Radio Engineers.

Liebmann was a kindly and loyal man. He was a great lover of family, of science, and the mountain peaks. His interest in science was wide, and his advice to colleagues and assistants has contributed greatly to their success. His powers of concentration were great. He was liked and admired by all. His memory will live with his friends because of his understanding and his sincerity, with his colleagues because of his example and guidance, and with his fellow scientists because of his scientific achievements.

He leaves a widow, a son and a daughter.

M. E. Haine

NEWS and VIEWS

Chancellorship of the Massachusetts Institute of Technology: Dr. J. A. Stratton

A new post, that of chancellor, has been established at the Massachusetts Institute of Technology, and Dr. Julius A. Stratton, at present vice-president and provost, has been appointed as the first holder. As chancellor, Dr. Stratton will be directly responsible for administering the academic side, including staff, of the Institute's affairs and will be deputy to the president, Dr. James R. Killian, jun., who is the Institute's chief executive officer; the chancellor will act as president in the latter's absence. The other principal officers of the Institute are Admiral Edward L. Cochrane, vice-president in charge of relations with industry and government, and Mr. Joseph J. Snyder, vice-president and treasurer. Dr. Stratton graduated from the Institute in 1923 and, after study in Grenoble and Toulouse, gained the D.Sc. of the Federal Institute of Technology, Zurich, in 1927. He became assistant professor of electrical engineering in the Massachusetts Institute in 1928 and then assistant professor of physics (1930), associate professor of physics (1935) and professor of physics (1941). He was on the staff of the Radiation Laboratory at the Institute from its inception in 1940 until the end of the Second World War. During the War he was at first engaged on communication surveys and other problems over the North Atlantic and in North Africa and Italy; later he advised on problems of ground radar, radar fire control and radar bombing, and assisted in the establishment of aids for all-weather flying. For these services he was awarded the Medal for Merit. After the War Dr. Stratton became director of the Research Laboratory of Electronics at the Institute, the peace-time successor to the Radiation Laboratory. He was made provost of the Institute in 1939, with the primary responsibility for co-ordinating inter-school educational and research facilities, and two years later he became vice-president as well.

Mechanical Engineering at Swansea: Prof. R. H. Macmillan

Mr. R. H. Macmillan has been appointed to the newly created chair of mechanical engineering at the University College of Swansea. Mr. Macmillan, who has been on the staff of the Department of Engineering at Cambridge for the past ten years, was educated at Felsted School and Emmanuel College, Cambridge, where he took the Mechanical Sciences Tripos in 1941. He was then commissioned in the Technical Branch of the R.A.F., where he was concerned mainly with automatic equipment for gunsights and with rockets. Since returning to Cambridge, he has published several papers on problems of automatic control, and his textbook, "An Introduction to the Theory of Control", first appeared in 1951. He spent the academic year of 1950–51 working as a visiting assistant professor in the Mechanical Engineering Department of the Massachusetts Institute of Technology, and on a later visit to the United States contributed to the Frequency Response Symposium of the American Society of Mechanical Engineers: on this occasion he also lectured on aspects of automatic control at the Universities of Pennsylvania and Minnesota. Mr. Macmillan's particular interest is in explaining engineering developments to other scientists and to the general public, and in considering their social implications; in this connexion the B.B.C. has broadcast a number of his talks, and last autumn he gave a popular series of afternoon lectures at the Royal Institution. His book, "Automation: Friend or Foe", has just been published by the Cambridge University Press.

Royal Society and Nuffield Foundation Commonwealth Bursaries

AWARDS under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme have been made as follows: A. B. Acton, assistant lecturer in genetics, University of Glasgow, to work in Toronto on the comparison of the chromosome conditions of Canadian populations of Chironomid flies with those in Britain (July–September 1956); Dr. W. R. Adey, senior lecturer in anatomy in the University of Melbourne, to visit neurological centres in Great Britain in order to extend his studies on temporal lobe epilepsy (December 1956–February 1957); Dr. L. Davies, lecturer in zoology, Durham Colleges in the University of Durham, to study blackflies and other biting insects, at Ottawa and Hamilton, Ontario (July 1956 for three months); J. Harley-Mason, lecturer in chemistry in the University of Cambridge, to investigate in Jamaica some West Indian plant products of potential chemical and medicinal interest (December 1956–April 1957); Dr. N. E. Hickin, of Leatherhead, Surrey, to visit Uganda during October 1956 to collect material for continuation of his studies of caddis flies (October 1956); Dr. A. Mohiuddin, reader in zoology in the University of Karachi, to study parasitic protozoa at the London School of Hygiene and Tropical Medicine (September 1956 for about twelve months); Dr. R. P. Rastogi, lecturer in chemistry in the University of Lucknow, to study at Reading and Edinburgh thermodynamic properties of mixtures (July 1956 for twelve months); Dr. W. M. Smith, associate professor of chemistry in Queen's University, Kingston, Ontario, to study at Oxford the kinetics of reactions in the liquid phase, with particular emphasis on fast reactions and the influence of the solvent (July 1956–June 1957); Prof. H. Waring, professor of zoology in the University of Western Australia, to investigate at Cardiff the influence of melanophore hormone preparations on carbohydrate metabolism, and particularly on the hyperglycæmia induced by adrenaline (October 1956–January 1957).

Ramsay Memorial Fellowships: Awards

THE Ramsay Memorial Fellowships Trustees have made the following awards for 1956–57: Dr. M. J. Stephen, a general fellowship at the University of Oxford; a Glasgow fellowship to Mr. G. S. Harris, at the University of Cambridge; a Canadian fellowship to Mr. A. H. Webster, at the University of Cambridge; a Netherlands fellowship to Dr. C. H. Stam, at the University of Leeds; and a United States fellowship to Mr. P. B. Sherry, at the University of Oxford. The Trustees have renewed the following fellowships for 1956–57: Mr. B. R. Hammond (general fellowship) at the National Institute for Research in Dairying, Reading; Mr. E. Haslam (general fellowship) at the University of Cambridge; Mr. H. Inokuchi (Japanese fellowship) at the University of Nottingham; Dr. R. Vicente and Mr. F. Garcia-Moliner (Spanish fellowships) at the University of Cambridge.

New Veterinary Building at Cambridge

A NEW building to house the Veterinary Investigation Officer and his staff of the Ministry of Agriculture, Fisheries and Food is to be constructed on the site of the School of Veterinary Medicine of the University of Cambridge. This was only made possible as a result of a gift of £10,000 by Lady Brigid von Preussen and her husband towards the cost of the scheme. The Veterinary Investigation Officer is responsible for investigating outbreaks of diseases among herds and flocks of the eastern counties of England. A great deal of clinical and pathological material is continually being sent to the centre for diagnostic purposes, and pressure of routine work not infrequently prevents the fullest use being made of this valuable material for research purposes. It was considered that contiguity of the centre with the School would help to overcome this and would facilitate collaborative research between the clinicians and pathologists of the School, on one hand, and with the veterinary staff of the Ministry's centre, on the other. Besides the value of the pathological material for teaching purposes, the student will inevitably be more likely to be introduced to the herd and flock problems of the surrounding counties by being continually brought into contact with the work of the Ministry's veterinary officers.

Westonbirt Arboretum

THE Forestry Commissioners have appointed the following as members of the Westonbirt Arboretum Advisory Committee: The Hon. L. Palmer (*chairman*), Sir Edward Salisbury, Sir Harry Champion, Mr. C. M. Floyd, The Duke of Beaufort, Sir Eric Savill, Prof. E. W. Yemm, Mr. Hiram Winterbotham and Mr. J. S. L. Gilmour. This arboretum, with some neighbouring woodland, was acquired recently by the Commissioners. It is situated to the south-west of Tetbury. It covers more than a hundred acres and is a unique collection of trees and shrubs; it was founded in about 1820 by the ancestors of the late Sir George Holford, by whom it was afterwards developed, the work being continued by the late Lord Morley. Oaks, yews and conifers form a background to numerous rare specimens of trees and shrubs collected from many parts of the world, particularly Japan, China and the western States of America, and including, notably, varieties of maple and rhododendron. The Committee will consider means of facilitating public access to the arboretum.

U.S. National Science Board

ON May 25 the United States Senate confirmed President Eisenhower's nomination of the following as members of the National Science Board of the U.S. National Science Foundation. Drs. L. M. Gould, P. M. Gross, G. D. Humphrey and F. A. Middlebush are charter members of the Board and have been re-appointed. Dr. Warren Weaver, of the Rockefeller Foundation, has been appointed to succeed the late Rev. J. B. Macelwane, and he will retire in 1960. The following have been appointed to serve a term of six years: Prof. E. J. McShane, professor of mathematics in the University of Virginia; Prof. S. M. Nabrit, professor of zoology, Atlanta University; Dr. J. A. Stratton, chancellor, Massachusetts Institute of Technology; Prof. E. L. Tatum, professor of biology, Stanford University.

Paris Academy of Sciences: Elections

THE following have been elected *correspondants* for the Botany Section of the Paris Academy of Sciences: Prof. P. Martens, professor of palæobotany in the University of Louvain, in succession to Prof. E. Gäumann, recently elected a foreign associate of the Academy; and Prof. A. Fernandes, professor of botany in the University of Coimbra, in succession

to the late Prof. E. D. Merrill. The following have been elected *correspondants* for the Zoology Section of the Academy: Prof. U. d'Ancona, professor of zoology in the University of Padua, in succession to Prof. D. Keilin, recently elected a foreign associate of the Academy; and Prof. P. Brien, professor of zoology in the University of Brussels, in succession to Prof. A. Vandel, recently elected a non-resident member of the Academy.

Recent Economies in Government Expenditure

The Chancellor of the Exchequer, Mr. H. Macmillan, made a statement about economies in government expenditure on June 26, in which he said that the estimated savings in defence (£36·5 million on the defence programme and £14 million on defence expenditure) do not reflect any change in the size or shape of the Armed Services and that any major decisions in this field would only be taken after consultation with Britain's allies. The savings of £25·5 million on other Civil Estimates, details of which are given in a paper afterwards circulated, include £810,000 in grants for Colonial development and welfare, including research, £70,000 in economies in capital expenditure by the Agricultural Research Council, £53,000 in economies in training and research and reduction in purchases of equipment by the Forestry Commission, £180,000 in economies in maintenance expenditure on roads and £150,000 in general economy by the Department of Scientific and Industrial Research. Economies of £265,000 by the Ministry of Housing and Local Government are to fall in part on National Parks. From the public point of view, it would seem that, where departments have been efficiently run in the past or have been short of adequate resources, the cuts though small will do real, if only marginal, harm.

Factory Inspectorate of Great Britain

Replying to questions in the House of Commons on June 26, the Minister of Labour and National Service, Mr. Iain Macleod, said that, of the ninety-six districts of the Factory Inspectorate, thirty-six have no inspectors possessing university degrees in engineering or chemistry and physics, and only eleven have more than one such inspector. For 1939, when there were ninety-two districts, the corresponding figures were twenty-four and twenty-three. Mr. Macleod said that the question of the technical strength of the Inspectorate is the most important matter now before him as a result of the departmental committee's report, and the problems are being considered whether the establishment of inspectors should be increased and whether more technically qualified people are needed.

National Science Foundation Russian Translation Programme

Expansion of the U.S. National Science Foundation programme for the translation into English of Russian research literature has recently been made through a grant of 76,500 dollars for this purpose to the American Institute of Physics. The expanded programme will include the *Zhurnal Teknicheskoi Fiziki* (*Journal of Technical Physics*), *Akusticheskii Zhurnal* (*Acoustics Journal*), and physics articles from the *Doklady Akademii Nauk SSSR* (*Proceedings of the USSR Academy of Sciences*). First issues of the translated journals will appear soon. The Foundation and the American Institute of Physics have already successfully collaborated in the publication of *Soviet Physics—JETP*, a bi-monthly translation of *Zhurnal Eksperimental noi i Teoreticheskoi Fiziki* (*Journal of Experimental and Theoretical Physics*), six issues of which have now appeared. In addition to the programme in physics, the Foundation is supporting translations of Russian papers in mathematics and biology; and plans for the fiscal year 1957 include the earth sciences and the engineering sciences. The American Mathematical Society publishes about 1,000 pages annually of Russian work in mathematics, under the title, *American Mathematical Society Translations*. The Foundation has just awarded a small grant to *Biological Abstracts* for the translation and publication of abstracts from the Russian journal, *Referativnyi Zhurnal: Biologiia* (*Abstract Journal: Biology*). During the last half of 1956 some 1,200 abstracts from Russian journals covered by *Referativnyi Zhurnal: Biologiia* will be translated by Consultants Bureau, Inc., of New York and reprinted in *Biological Abstracts*. The abstracts will be drawn from thirty-one primary journals covering a wide range in the field of biology.

Science Museum Collection of Time-Measuring Instruments

The interest shown in the collection of exhibits at the Science Museum, London, illustrating the measurement of time has called for a third, revised and expanded, edition of the descriptive catalogue of the objects exhibited in the Time Measurement Section of the Museum (pp. 102+10 plates. London: H.M.S.O., 1955; 6*s*. 6*d*. net). The second edition was published in June 1950. Part 1 of the handbook, entitled "Historical Review", which is published separately and which in its third edition was reprinted last in 1952, consists of a brief review of the history of time measurement together with notes on the principles employed in measuring time. Part 2, the "Descriptive Catalogue", contains the substance of the descriptive labels exhibited with the various objects in the Museum. The collection is classified into twelve large groups, which are further divided into sub-groups, and 463 exhibits are listed (compared with 390 in the second edition), together with some eighty other objects not on exhibition. A new section deals with time recorders, that is, instruments which make a printed record of the time of day at which a certain event takes place. Many of the collection of more than seventy sand-glasses, presented to the Museum in 1952 by the Rt. Rev. Abbot Horne, of Downside Abbey, are now included in the Museum exhibition, in addition to several new exhibits in almost every section. The illustrations in the handbook are the same as in the previous edition, but the illustration on the cover has been changed from a reproduction of a sixteenth-century weight-driven domestic clock to that of a 1718 garden sundial. The price is double that of the previous edition.

Rapid Analysis of Silicate Rocks

During recent years the United States Geological Survey has been faced with the problem of achieving a greatly increased output of chemical analyses at a time when the demand for analytical chemists much exceeded the supply. To circumvent this impasse, rapid analytical methods have had to be devised. The procedures described in Bulletin 1036-C of the Survey, "Rapid Analysis of Silicate Rocks", by Leonard Shapiro and W. W. Brannock (pp. 56. Washington, D.C.: U.S. Government Printing Office, 1956; 20 cents), provide for the analysis of the

thirteen oxides most commonly determined in silicate rocks by simple direct methods which can readily be learned by relatively untrained personnel and which give results several times faster than formerly. Most of the determinations depend upon the use of a spectrophotometer, flame photometer, or automatic photometric titration equipment. The booklet will be welcomed by geologists and mineral chemists with experience of the tedious and time-consuming routine of conventional rock analysis.

Ethnographic and Archæological Survey in Angola

An ethnographic survey in the Kioko (Bachioko) region of Angola, made by José Redinha, curator of the Dundo Museum, has been published by the Diamond Company of Angola under the title of "Campanha Ethnográfica au Tchiboco (Alto-Tchicapa)" : Pt. 1, "Notas de Viagam" (pp. 175 + 5 plates) ; Pt. 2, "Aratacoes e Documentacao Gráfica" (pp. 214) (Museu do Dundo, Publicaçoes Culturais No. 19. Lisbon : Companhia de Diamantes de Angola). The first volume contains the itinerary of the expedition, with ethnographic and archæological details on the people and their country. The second volume is a magnificently illustrated catalogue of the objects collected, together with supporting notes on the arts and crafts of the region. This volume, with its wealth of illustrated detail, should be of considerable value to curators of ethnographical museums and to those interested in the comparative study of the material culture of Negro Africa.

University of Sheffield

The following appointments have been made in the University of Sheffield : J. P. Duncan (lecturer in mechanical engineering in the University of Manchester), professor of mechanical engineering ; Dr. G. Weber, senior lecturer in biochemistry ; Dr. I. C. Browne, lecturer in physics ; Dr. D. J. Harris, lecturer in electrical engineering. The following resignations have been announced : Dr. J. Lewis, lecturer in chemistry ; Mrs. H. G. Knowles, map curator and librarian in the Department of Geography.

The Council of the University has accepted an offer by Boots Pure Drug Co., Ltd., to provide a medical research fellowship of the annual value of £1,000 for a number of years. The London Tin Corporation, Ltd., is providing a research fellowship in metallurgy, which has been awarded to Dr. B. B. Argent. Other research fellowships have been awarded as follows : Owens-Illinois Research Fellowship in glass technology to Dr. N. E. Richards ; Oldham Research Fellowship in mining to A. G. Neill.

The Council has approved a proposal by the Medical Research Council to establish a Unit for Epidemiological Research on Respiratory Diseases (Air Pollution) in the University. The Unit will be under the direction of Dr. J. Pemberton, senior lecturer in social and industrial medicine.

Announcements

Mr. G. H. Greenhalgh has been appointed British scientific attaché in Scandinavia, in succession to Mr. R. G. Silversides, who is returning to the headquarters staff of the Department of Scientific and Industrial Research. Mr. Greenhalgh is on loan to the Department from the Atomic Energy Research Establishment, Harwell.

To commemorate the occasion of the diamond jubilee of the *British Journal of Radiology*, the following have been elected to honorary membership of the British Institute of Radiology : Mr. Cuthbert Andrews ; Sir Russell Brain ; Dr. Russell J. Reynolds ; Dr. F. Gordon Spear.

Four new appointments have been made to the staff of the U.S. National Science Foundation. Dr. E. E. Litkenhous becomes programme director for engineering sciences ; Dr. Frank K. Edmondson, programme director for astronomy ; Marguerite Risley, professional assistant for the astronomy programme ; and Dr. Robert R. Brown, professional assistant for the physics programme.

The British Mycological Society will hold its thirtieth annual plant pathology field meeting in the Nottingham district during July 27–28. Visits will be made to the University of Nottingham Department of Agricultural Sciences, at Sutton Bonington, Loughborough, and to the Boots Lenton Experimental Station, Nottingham. Four papers will be read in the Botany Department of the University. Further information can be obtained from Dr. G. J. F. Pugh, Department of Botany, The University, Nottingham.

The Faraday Society has arranged a general discussion on "The Physical Chemistry of Processes at High Pressures" to be held in the University of Glasgow during September 20–21. After a general introduction by Prof. A. R. Ubbelohde (Imperial College, London), there will be three sessions on the following topics : equations of state, physical properties and thermodynamic transformations ; chemical reactions and transformations at high pressures ; and detonation and other high-temperature phenomena at high pressures. Proofs of papers will be circulated in advance of the meeting. Further information can be obtained from the Secretary of the Society at 6 Gray's Inn Square, London, W.C.1.

The Teyler's Foundation and the Teyler's Second Society, Haarlem, are offering jointly a prize for an essay on "The absolute relations, on time and space, between actual events, as brought to light by the theory of Einstein, and the interest which the new insight concerning these might have for views in other domains of knowledge". The prize will consist of a gold medal, worth 400 Dutch florins, or, if the recipient prefers it, this amount in cash. The essays may be in Dutch, French, English or German, and must be submitted by January 1, 1957. Further information can be obtained from the Directeuren van Teylers Stichting, Fundatiehuis Damstraat 21, Haarlem, Netherlands.

The Department of Industrial Engineering of the Loughborough College of Technology is starting, as from September next, a new postgraduate course in industrial engineering. The course will last one year and will cover a wide range of advanced management topics. In addition, some special subjects will be dealt with, including nuclear energy and automation, which will be approached from the technological point of view ; there will also be sessions on men and machines, which will be concerned with the physiological effects of noise, fumes, dust, vibration, etc. The course is suitable for senior personnel from all types and branches of industry. Further information can be obtained from the Head of the Department of Industrial Engineering, Loughborough College of Technology, Loughborough, Leicestershire.

IMPLICATIONS FOR BRITAIN OF DEARER COAL

THE British public have recently been shocked again by a substantial increase in the price of coal. A figure of 8 per cent increase has only to be repeated a few more times and a serious situation in industry may be realized, for coal must remain, in spite of the marked increase in the use of oil in all branches of industry in Britain in recent years, the basis of Britain's economy. The really serious feature of these repeated unfortunate movements in price is the impetus that the rise in the price of coal gives to price- and wage-increases everywhere. Unfortunately, there are economists who believe that a rise in the price of coal is the most effective means of inducing more efficiency in the use of coal. The fallacies of these views when applied to the existing situation are being abundantly shown by the sequence of events that seem to have become a repetitive feature of our present times. They occur in spite of the trend to replace coal by oil because the outlook reveals a possible increase in the shortage of coal occasioned by still greater demands for power in industry if Britain is to maintain her competitive position in world export markets. As a further feature of the trend towards the use of oil, there is the Prime Minister's recent warning of the danger of war that might arise from the need for the maintenance of oil supplies from the Middle East—a sorry picture and prospect for a country whose greatest mineral asset lies in her coal measures.

The *Financial Times*, in a leading article of May 29, directed attention to the fact that the formidable burden that is being forced upon British industry by the impact of dearer fuel, power and transport comes at a time when other raw materials are showing a downward trend in price—copper down 30 per cent from this year's peak, tin 16 per cent, lead and zinc 11 per cent below their 1956 peak and rubber 38 per cent. Wage increases are not in the present case the only cause of the rise in price, for the nettle of the accumulated deficit in the costs of raising coal and costs of the mine reconstruction programme had to be grasped, and the sooner the better. Where lie the remedies? Technical advances in fuel utilization have in the past contributed in a substantial measure to the advancement of Britain's economy; but such instruments of progress can only move at the natural rate at which the means in the form of finance and technical personnel become available. Thus the call for more technologists can only meet with response in the course of years, as in the case of the development of the use of atomic energy. Meanwhile, the situation promises to become desperate, bearing the threat of the effect of foreign competition in export markets. At the moment, the only sure sign seems to be that the loss of such markets is going to be the determining factor in the situation.

There does, however, remain one saving grace: the inherent good sense of the British race, and the strange ability to 'muddle through' in times of trouble. Put in more conventional, if less expressive, form, both the industrialist and the working man, when they finally recognize a dangerous situation, have a tactical genius for mastering that situation. They do the job another way to save both heat and energy, and, if necessary, labour. Thus 'automation' to the journalist may be a magic word whereby to scare the uninitiated in a headline; to the engineer it is mechanization and instrumentation, employing techniques which he has probably been developing for many years. In spite of many statements to the contrary, Britain is as highly skilled in these arts as any other country. In such directions lie the ultimate solutions of our problems of rising costs, aided by the inherent characteristic of refusing to panic, however black the approaching cloud.

R. J. Sarjant

THE FUTURE OF METALLURGY

AT the annual general meeting of the Institution of Metallurgists, held on May 15, Mr. G. L. Bailey, director of the British Non-Ferrous Metals Research Association, was installed as the new president. In his address, Mr. Bailey, after discussing the progress of the Institution, went on to consider the rather distant future of the metallurgical industries.

The vast majority of metals are used for traditional purposes which are neither particularly spectacular nor exciting; but if, for example, we were compelled to carry on without steel, copper or cast iron, the question of finding suitable substitutes would in many cases be surprisingly difficult. If the demand for a specific metal exceeds the supply, the first thing to happen is a change in what is, somewhat deplorably, known as 'the pattern of use'. In the first place, more readily available metals, such as aluminium, magnesium and, maybe, titanium, would come into more extensive use, and secondly, there would be increasing employment of non-metallic materials for purposes for which metals were previously used. These are matters both of economics and of technical efficiency—if a plastic pipe has advantages over a metal one at the same price, it will be used. If it is not so good but a lot cheaper, it will still be used to some extent. This balance is an ever-changing one as new properties are discovered and new methods of production developed.

This factor, new methods of production, is one of basic importance. In connexion with estimates of known resources, it must be borne in mind that the detailed prospecting of ore body is usually carried out merely to ensure an adequate supply for a specific and limited term of years. As a result of some change of price, of the development of new methods of beneficiation or of extraction process, enabling a poorer grade of ore to be used more efficiently, what may not now be an economic ore body may well become one in the future. Aluminium, for example, is to-day produced from bauxite; but there are immense amounts of aluminium available in clays which could not, however, be used with existing knowledge except at much higher cost.

It is considerations of this kind which make it so difficult to forecast the distant future with that degree of assurance adopted by some people with less knowledge of the metallurgical industries.

Apart from traditional ones, there are emerging a series of spectacular uses of metals which will control the whole of the future development in many fields of engineering. It is yet to be seen how far alloys based on the newer metals can be produced with properties which have hitherto been unobtainable, and a vast, indeed unlimited, field of metallurgical endeavour is thus opened out.

The big competitor with the metals would appear to be the plastics, particularly when suitably reinforced, and in some quarters there is the assumption that these will go on getting better and cheaper, while the metals themselves are becoming increasingly scarce. It is by no means certain that this somewhat superficial view can be justified. Given sufficient energy, imagination and enthusiasm on the part of the metallurgist, the metals, by improving the methods of extraction and fabrication, can also, perhaps, become cheaper; and new alloys of better properties will most assuredly be developed. It is Mr. Bailey's forecast that the future of the use of metals, both for the more spectacular purposes of modern engineering, and for the older, traditional ones, is not only assured but also full of interest and, in places, definitely exciting.

THE IMPACT OF ENGINEERING ON SOCIETY

FOR the second Graham Clark Lecture, delivered to a joint meeting of the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Electrical Engineers at the Institution of Mechanical Engineers on April 27, Sir Maurice Bowra, vice-chancellor of the University of Oxford, chose to speak on "The Impact of Engineering on Society", pointing out that almost every society of which we know practised engineering to some degree. A considerable degree of civilization can be secured with a minimum of engineering; but a society which does not believe in engineering, or see its possibilities, is, as the failure of the Greek and Roman systems shows, unlikely to survive. Civilization is a sensitive plant, and its first duty is to look after itself. Sir Maurice suggests that the trouble with the Ancient World was that it never had any difficulty in finding men to do tasks which we assume should be done by machines, and the educated and governing classes accordingly never turned their minds to other, and better, ways of getting work done. That the Romans, like the Chinese, rejected machines in the last resort because their ruling classes were snobs is a social fact of first importance, and Sir Maurice proceeds to demonstrate its relevance to modern times, and to show how economic forces played an important part in securing recognition of the idea that machines can do much that men cannot do by themselves and in creating opportunities for the engineer.

This great change, however, has not been revolutionary in the political sense, although it has changed the whole appearance, and even the structure, of society. Engineering is not a political activity; it aims instead at the control and exploitation of natural resources to give a greater degree of human welfare, and it becomes political only when its existence is threatened by authority or when it is taken up by authority for its own sake. Indeed, within the limits of the social frame and national States within which the engineer works, his work has a strong stabilizing influence; and so far as engineers must share the blame for man's failure to evolve means for satisfying his desire for security and prosperity, it is for sins of omission rather than of commission.

In Sir Maurice's opinion, engineers have taken too modest a view of their own task and duties. More than any other branch of human activity, engineering provides an imaginative equivalent to war and has the advantage that it creates instead of destroying. Engineering, however, contributes much towards the drive towards uniformity and the destruction of that rich variety of experience which characterizes the great humanistic tradition; and it is a serious charge that the influence of engineering interferes with the variety of the individual self and shapes it to a uniform mould by imposing on it certain patterns through modern methods of indoctrination such as the press, cinema, wireless and television. Sir Maurice questions, however, whether such means will retain their ability to impose uniformity, and he also finds grounds for hope in the undeniable tendency of men to pursue the specially difficult task of thinking for themselves.

Engineering may in the end make it easier for thought to be free, and, while admitting that engineering tends to impose a standard of culture which lacks the variety and beauty of the old craftsmanship, Sir Maurice also sees no reason why a world that relies on machines more than on handicrafts should not produce objects as satisfying as those of the old craftsmen. Because they will give delight to a far greater number of people, a new kind of grace and charm may emerge, and if men really were to know what are the ends to which he would be able to turn Nature, he should be able to do on an ever extended scale what he has already begun to do with such imagination, devotion and skill.

HEALTH HAZARDS IN THE COAL AND CHEMICAL INDUSTRIES

THE first provincial meeting of the British Occupational Hygiene Society was held in the University Hall, Liverpool, during April 19–20. In his presidential address, Dr. C. G. Warner, dust suppression scientist of the South Western Division of the National Coal Board, spoke of the satisfactory progress of the Society, an indication that by practical activities it is fulfilling its aim of promoting the science of occupational hygiene. Dr. Warner went on to talk about the remarkably changed situation regarding pneumoconiosis in coal mines which has been occasioned, on one hand, by increased awareness of the disease and, on the other, by measures taken for suppressing airborne dust.

South Wales was formerly a bad area, and after 1943, when the legal definition of pneumoconiosis was relaxed, the rate of certification rose to a peak figure of 55·6 men per thousand employed; by 1947 it had fallen to 30·8. Meanwhile, in the rest of

Britain the corresponding figure for 1947 was only 1·9 men certified per 1,000. As knowledge of pneumoconiosis spread, the number of cases reported in other parts of Britain rose from 597 in 1945 to 3,542 in 1954. The rapid improvement in dust control had its effect, however, and the number of cases in South Wales fell from 5,224 in 1945 to 927 in 1954. Many years elapse before the disease can be detected in a coal miner, even when he is working under dusty conditions, and the present victims accumulated most of the dust load in their lungs some time ago. Such conditions are by now almost eliminated, and it is expected that in twenty years time only the mildest type of pneumoconiosis will continue to be encountered.

The first paper at the meeting was read by H. Pirie, of the Technical Service Department, General Chemicals Division, Imperial Chemical Industries, Ltd., his subject being the production and uses of chlorine. Chlorine was formerly transported as bleaching powder; but, since its use as a war gas in 1915, it has been transported as liquid, and many tens of thousands of tons a year are now handled in tanks, drums and cylinders. Many users, such as waterworks operators or baths superintendents, have no technical experience, and rules have been devised for their protection. The important points are as follows. (1) Liquid chlorine must be dry, and the packages and valves foolproof. Filling ratios must be observed, and containers serviced and tested regularly. (2) The customer should know how to use the product and to handle the packages safely. His drum and tank installations require initial inspection, and instruction and precaution cards are issued. (3) The customer should know what to do in the event of an accident. A chlorine emergency service is available to deal rapidly with trouble at the premises of any user. (4) Regular visits to the customer are made to ensure that the necessary precautions are being taken.

Trichloroethylene is one of the oldest of the commercially available organic compounds of chlorine and the one made on the largest scale. It is less dangerous than many others because it has no chronic effects. It has many uses in industry and can be used safely provided simple precautions are taken.

Mr. Pirie also referred to the system of labels for hazardous products devised by the Association of British Chemical Manufacturers. These are intended to protect the transporters of such substances—railway employees, lorry drivers, storekeepers, etc. They are distinctive and easily recognizable, name the particular hazard, describe its nature, and give simple precautions to be observed in case of spillage, fire or other accident.

The next paper, on the technique of particle measurement in industrial hygiene, was delivered by G. L. Fairs, of the Research Department, General Chemicals Division, Imperial Chemical Industries, Ltd., who described various established methods of taking samples of dust. These included isokinetic sampling downstream of a mixing baffle, sampling in ducts, and the horizontal elutriator for size separation. Cells for sampling mists containing particles liable to change in size by evaporation or condensation were also mentioned.

Dealing with microscopic analysis of samples, Mr. Fairs stated that below 1 micron it is impossible to differentiate between the images of larger particles and diffraction haloes of much smaller ones; the electron microscope should replace the visual instrument for studying fine dusts. Sedimentation analysis, based on Stokes's law for the rate of fall of particles in liquid, suffers from the disadvantage that samples of the different size fractions remaining in suspension become very attenuated towards the end of the process and their removal creates a disturbance. An apparatus was described which is better in these respects, since it works by flushing out the settled particles for estimation.

Elutriation, by blowing air through a powder to carry away fine particles which settle more slowly than the air speed, enables size fractions to be determined by filtering the effluent and repeating at decreasing rates of flow. It has been found that 30 seconds of blowing is often sufficient to give adequate separation with the powder on a gauze support in a cylindrical elutriator tube.

The final paper was read by Dr. J. D. Paterson, of the Medical Department, General Chemicals Division, Imperial Chemical Industries, Ltd., and dealt with hydrofluoric acid. He said that considering only the acute effects, and ignoring the chronic, this compound must be regarded as even more severe in its action than mustard gas. In designing plant, the possibility of hydrofluoric acid coming into contact with the operators should be reduced to a minimum. In addition, to guard against mischance, adequate protective clothing is provided, means of decontamination are available, and effective medical supervision is at hand.

The acute hazard is associated with concentrations above 20 per cent, which damage body tissues; acid stronger than 60 per cent causes damage which is immediately apparent. A unique effect with hydrofluoric acid is its power of penetration to a depth where it exerts a dissolving action on cellular membranes, causing liquescent necrosis and decalcification of bone. Pain is very severe and may be immediate or delayed for some hours, according to the strength of the acid. Treatment consists of washing with copious amounts of water followed by a dressing of magnesium oxide paste. This is usually sufficient for mild burns. Injection of 10 per cent calcium gluconate into and around the burned area until there is weal formation relieves more severe cases very rapidly. Dr. Paterson has not found it necessary to give an anaesthetic before injecting. Protective clothing requires careful inspection. The majority of burns are caused by pinholes in gloves which get hard wear.

The chronic hazard is the possibility of fluorosis, which is a condition of sclerosis of bone and, in extreme cases, ossification of the ligaments. Protective clothing, including a fresh-air hood to prevent inhalation of vapour, is an insurance against fluorosis; but when the hydrofluoric acid plant of Imperial Chemical Industries came into production, a weekly urine test and estimation of fluorine content were established. The risk of fluorosis is slight when the fluorine is below 10 mgm./l. of urine, and the policy of the firm is to take 1 mgm.l. as a safe excretion-rate. It soon became apparent that the excretion-rate of fluorine was so high that daily measurements were necessary to detect peaks. After a time, these observations provided a valuable indication that all was well with the plant, and enabled small defects, which would otherwise have passed unnoticed, to be rectified. In spite of all precautions, the Medical Department still has to treat an occasional hydrofluoric acid burn, usually due to a faulty glove; but it has never had a serious case, nor a burn of the eye. Dr. Paterson also referred to chlorine and bromine trifluorides, which

are very reactive and produce thermal burns in contact with the skin, but do not penetrate in the manner of hydrofluoric acid.

The meeting concluded with a film illustrating the work of the General Chemicals Division of Imperial Chemical Industries, Ltd., and members of the Society were conducted around the Castner-Kellner and Rocksavage Works on the following day.

C. N. Davies

SOUTH-EASTERN UNION OF SCIENTIFIC SOCIETIES

ANNUAL CONGRESS IN TUNBRIDGE WELLS

THE South-Eastern Union of Scientific Societies held its sixty-first annual congress in Tunbridge Wells during May 24–27 under the presidency of Dr. W. E. Swinton. The Tunbridge Wells Natural History Society was the host society, and the choice of Tunbridge Wells for this year's meeting was particularly appropriate since the first congress of the Union, on the occasion of its foundation sixty years ago, was held there in April 1896.

At the young naturalists' evening, a panel of experts answered questions ranging from the cause of the glowworm's glow to the evolution of group flying, as with starlings in the autumn. Major Maxwell Knight showed his film of the hand-rearing of the cuckoo.

The Archæology Section was addressed by Major J. M. T. Burchell, his subject being the archæology of the Medway Estuary. He emphasized that geological evidence precluded the possibility of the manufacture of pottery, during Roman times, in the area and said that kilns have not been discovered. The creeks in the marshes were, during that period, used for trading purposes, and the abundance of material found, including the Upchurch ware, can probably be attributed to this source. Major Burchell afterwards conducted the party to Addington to view the work being carried out in the investigation upon a long barrow, where probing for outlying stones and digging to expose them is in progress. A visit was also made to Coldrum, an excavated long barrow, now in the care of the National Trust.

The president of the Zoology Section, Dr. H. R. Hewer, in his address spoke on the importance of keeping field records. He said that the natural sciences are primarily observational rather than experimental, and therefore the facilities of a laboratory and high technical training are not essential. The glory of zoology is, in the main, due to the amateur field naturalist, Darwin and Wallace being examples. The great period of accurate observational work in zoology was from 1850 to 1900, undertaken in an endeavour to determine the ancestry of species. To-day the emphasis is upon ecological studies, where natural observation with statistical correlation is of primary importance. The Zoology Section's excursion was to High Woods and Scotney Castle, by permission of Mrs. Hussey, under the leadership of Dr. L. B. Langmead.

Dr. Swinton chose as the title of his address, "Nature and the Free Mind". He began by pointing out that practical scientists at every level should be concerned with the history of science and should not leave it to the historians and philosophers. The collation and preservation of local records and the need for sharing field problems call for the national provision of finance and apparatus to help these valuable studies. Perhaps the most important role is to contribute to the understanding of the place of science in the community. While there is no need to stress some of the benefits that accrue from the advance of research, there is, at the same time, the undoubted fact that many people believe that science is something inevitable and complete, and that persistence is all that is needed to reveal the whole truth. It is salutary to remember that the rise of science was fortuitous. The ready acceptance of Darwinism may have been the result of the recognition of the power of scientific discovery as revealed in the Great Exhibition of 1851. Science tries to explain itself; but the symbols involved are frequently beyond the intelligibility of the public. The philosophers have maintained that, despite this, science is irrational, although that same public is now the patron of natural science. Yet, unlike religion, philosophy, manners and customs, science is nationally transferable, and the practice of its deleterious forms can be undertaken by backward people. A substantial increase in the numbers of servants, students and practitioners of technical science to enable Great Britain to compete in the world will be aided by an appreciation of the limitations of the various disciplines. The facts of science are neither good nor bad inherently, but are in accordance with their uses in human hands. Much scientific apparatus is limited in its application by the receptive qualities of the human eye, so there are similar limits to human intelligence, perception and morality. One of the major needs in our community is the realization that science is not a juggernaut come to crush its sponsors and creators, and, above all, it is still capable of being moulded into the instrument, not the master, of mankind. Despite discoveries and formulæ, there is still room for the freedom of the mind.

The address to the Botany Section was given by Prof. C. T. Ingold, speaking on "Gasteromycetes, or Nature tries again". He discussed the disparities of numbers in genera and species, saying that, while the numbers of genera of Hymenomycetes and Gasteromycetes differ slightly—170 in the former to 110 in the latter—there is a difference of more than ten to one in the number of species—6,900 Hymenomycetes, 630 Gasteromycetes. He suggested that, upon the evidence of spore distribution, it is probable that the Gasteromycetes have evolved from the Hymenomycetes by a process of degeneration. The members of the Section visited Saxonbury Hill and Ashdown Forest, where the rarer plants present were shown and described by Dr. Francis Rose.

The president of the Geology Section, C. C. Fagg, described the swallow holes in the Mole Gap and their effect upon the river flow and the water supply available over an area of 130 square miles with an average annual rainfall of 30 inches. The water-level is below the river bed, and the table is maintained by seepage rather than by the swallow holes, although there are twenty-nine of these still active, some being on the bare Chalk. Prof. S. W. Wooldridge, speaking on the geomorphology of the Central Weald, urged the reconsideration of the generally accepted theory of the Wealden anticline. He demonstrated that, instead of a simple anticline, there is a complex structure with at least six anticlines. Considering the effect of these upon subsequent denudation, particularly upon the direction of the flows of rivers, text-books dealing with the matter should be re-

written and a different exposition to the existing one should be given by teachers of geography and geology.

Excursions were conducted to Eridge Park and Costume Museum, and to Lewes, where the historic buildings were described by Mrs. E. Bradley, while material of interest to the botanists and zoologists on the Levels was shown by Dr. Langmead.

The sixty-second annual congress of the Union will be held next year in Hastings during April.

NATIONAL RESEARCH DEVELOPMENT CORPORATION

ANNUAL REPORT FOR 1954–55

THE report and statement of accounts of the National Research Development Corporation for the year ended June 30, 1955*, records only 135 cases of assignment of United Kingdom patent rights to the Corporation by government departments and research councils, compared with 315 during 1953–54. Of the 597 inventions communicated to the Corporation during 1954–55 (compared with 664 during 1953–54), 203 were from government departments and research councils, 22 from official organizations of the British Commonwealth, 8 from industrial research associations, 54 from universities and 310 from private firms and individuals, 283 of which were British. Patent rights assigned to the Corporation during the year totalled 187, including 42 from universities and 9 from industrial research associations; holdings of British and foreign patents and patent applications at June 30, 1955, included 492 United Kingdom applications and 522 granted patents, and 982 overseas patent applications and 639 granted patents. The accounts show a rising trend in the return from the Corporation's activities when compared with its outgoings, the annual income of £94,749 during 1954–55 representing 61·3 per cent of the expenditure.

Of the projects initiated in previous years, the report notes that four of the six big electronic digital computers had been delivered, installed and accepted by June 30, 1955. The '401' computer, leased to the Agricultural Research Council, continues to operate satisfactorily at Rothamsted Experimental Station and has also been used in developing a numerical technique for predicting the predisposition of an aircraft to aerodynamic 'flutter', in which it has been demonstrated that the flutter speeds and frequencies may be conveniently and quickly computed by digital equipment. In addition, it has been used for computing the optimum trajectories of particles under acceleration in a cyclotron, with contributions to the understanding of cyclotron design. The response to grants for training computer engineers at the Universities of Manchester and Cambridge has been small. Uncertainties of marketing conditions and the absence of firm orders appear to be the chief barriers to obtaining licences for the Ricardo light steam engine, and prototype installations were being placed at the disposal of some Commonwealth governments for field trials and demonstrations. The production of hecogenin from sisal has been transferred to firms engaged in the industry on satisfactory commercial terms, and cortisone is being produced from the hecogenin now available. In view of the favourable report of a firm of chemical engineering consultants, the Corporation is continuing to support the acetylene synthesis project at the Imperial College of Science and Technology, London. Development of an experimental prototype stereoscopic motion-picture camera was completed during the year, and the camera is extremely promising.

Of the new projects, the Corporation is supporting an extended design study at the Manchester College of Technology of the possibility of controlling machine tools directly with a digital computer, and is sponsoring the development and initial marketing of Prof. H. S. Lipson's optical diffractometer. It is also financing the research and development work on the application of Prof. G. Pontecorvo's technique for synthesizing new strains of non-sexually reproducing micro-organisms, and is participating in a joint project with the Department of Scientific and Industrial Research and the Herring Industry Board to develop full-scale prototype equipment for commercial trials of new techniques of fish-smoking. Established projects now proving a useful source of revenue include those on the Bailey bridge, the Denny-Brown ship stabilizer, a technique for light-alloy cutting by electric arc, an air-position indicator, a course-setting dial-adjustment for aircraft, a backward-travelling-wave tube, a signalling system for teleprinter operation over radio links, a synthetic resin stoving enamel, a fire-fighting foam from degraded animal protein materials, a composition tablet for rendering brackish or sea water drinkable and an improved synthesis of an intermediate required in the production of the anti-malarial, 'Derraprim'.

* National Research Development Corporation. Report and Statement of Accounts for the Year 1st July, 1954, to 30th June, 1955. Pp. ii + 20. (London: H.M.S.O., 1956.) 1s. net.

UNIVERSITIES COUNCIL FOR ADULT EDUCATION

REPORT FOR 1954–55

THE report of the Universities Council for Adult Education for the session 1954–55* is critical of the Ashby report of adult education in Britain on two points: it has serious doubts regarding the administrative arrangements proposed for the annual assessment of grants to responsible bodies; and it regards the recommendation that a committee should be set up to advise the Minister of Education on the subjects and types of adult education courses which should receive priority in qualifying for grants as a serious threat to the academic freedom of the universities. The Council re-asserts its conviction that responsible bodies must truly exercise the responsibility of determining the form and content of their programmes, in shaping which consultation with the Ministry is always welcomed. When the Minister of Education intimated his acceptance of the recommendations of the Ashby Committee, this particular recommendation was specifically excepted, and friendly discussions with the Ministry have led to a mutually acceptable arrangement for assessing grants. The new Further Education Grant Regulations, issued in July 1955, contained the statement, according with the cardinal recommendation of the Ashby Committee for more active but flexible control of expenditure by the Ministry, that "in determining

* Universities Council for Adult Education. Report on the Year 1954–55. Pp. 24. (From the honorary secretary and treasurer, W. E. Salt, University of Bristol, 1956.)

the amount of grant the Minister will have regard to the general standards of the courses, the needs of the area, the activities of other bodies providing further education in the area and the fees paid by students". The report remarks that it is to the sense of partnership built up, over the years, between the Ministry and the responsible bodies that we must look for a solution of the difficult problem of maintaining a reasonable control over expenditure while preserving the due rights and responsibilities of the responsible bodies.

During the session under review the Minister was able to relax somewhat the severe limitations on grant-aid during the previous two sessions and, in particular, to give some assistance towards the mounting cost of tutors' salaries. Most extra-mural departments of universities at the end of the session reported a slight increase in the number of courses provided, the total of 4,302 exceeding the peak of 4,116 in 1950–51, while the number of students increased from 78,672 in 1953–54 to 84,752. The increase was largest in short courses of three to nine meetings (19 per cent) and smallest (0·9 per cent) in tutorial classes; sessional classes increased by 6 per cent. There was an increasing tendency, particularly in tutorial classes, to provide tutorial and sessional classes outside the traditional framework of collaboration with the Workers' Educational Association, and all this expansion has been achieved mainly with the help of part-time tutors, who increased in number from 2,342 to 2,768, 1,127 being university teachers; university lecturers appear to have been responsible for 57 per cent of the tutorial classes and 48 per cent of the sessional classes.

The extension lecture course is still an important element in most extra-mural programmes; but the majority of universities now use short extension courses in the broad field of the liberal studies as a means of interesting the general public in some aspect of university study and keeping those already interested abreast of recent developments. Such courses are often given by a team of lecturers. A variety of courses has also sprung up to provide for serious study by other kinds of student groups, particularly those with a good background of previous education. Many courses of the extension tutorial or study course type are provided in collaboration with societies or professional organizations, and an increasing proportion of extension courses is now run in this way. While some of these courses have a strong vocational appeal, all are liberal in subject-matter and treatment. In the post-war years, however, the universities are also providing courses directed to providing specific vocational groups with information on recent advances in university studies, especially in science and technology, mostly at a postgraduate standard. A striking feature of post-war development is the increasing use being made by extra-mural departments of residential courses, while there is now a remarkable amount of coming and going between Great Britain and foreign countries in the field of adult education. As regards subjects of study, the largest increases in the number of courses have been in the physical sciences (26 per cent), religion (17 per cent), history (12 per cent) and international affairs (12 per cent); the decline in psychology (5 per cent) and geography (10 per cent) has continued, and there has been a sharp contraction (31 per cent) in government. The demand for history is mainly for local history or archæology, and the study of languages appears to be on the increase. Interest in the social studies is much less marked, and the substantial increase in science courses is largely vocational.

Besides the Ashby report and the new regulations, the Council discusses the report on broadcasting and adult education prepared by Mr. Maurice Bruce and is concerned about the provision of books to adult classes. Its own inquiry in England and Wales has indicated that all thirteen universities and three of the eight university colleges have their own extra-mural libraries, usually administered separately, whether or not they are part of the university or college library. Issues to book boxes ranged between 2,000 and 10,000 volumes a year, and expenditure between £200 and £800 a year, with substantially higher figures for London and Oxford. Five of the sixteen extra-mural libraries supplied 90 per cent or more of the books required by classes; three between 70 and 90 per cent; and three between 50 and 70 per cent. In four instances 20–50 per cent of the supply came from the National Central Library and few libraries did not make some use of the National Central Library.

THE NATIONAL VEGETABLE RESEARCH STATION

OPEN DAY

THE first open day of the National Vegetable Research Station was held on June 5 at Wellesbourne, Warwickshire, when visitors saw the progress made in the development and work of this Station. Field experiments were on view, and there were exhibits of various aspects of the research in progress.

The Plant Breeding Section illustrated how it is using inbreeding, followed by the crossing of inbred lines, in an attempt to produce hybrid varieties of Brussels sprouts having improvements in uniformity, yield and other characters over ordinary varieties. Male sterility is being used as a helpful tool in this work, as it is also with onions, in the production of hybrid seed. The cause of deterioration of varieties of brassicas is also being investigated. F_3 progenies from crosses between lettuce varieties and a wild species, *Lactuca altaica* Fisch and Mey, which showed little attack by mosaic virus, were exhibited. These progenies were raised from the small proportion of F_2 plants which remained mosaic-free when grown in an epidemic of the disease. Stages in the process of breeding a non-bolting, high-quality variety of red beet having single-seeded fruits were shown, also work in the production of asparagus which should give only male plants from seed instead of the usual 1 : 1 ratio of male and female. Breeding material of forcing radish, spring cabbage and early cauliflower was also exhibited.

Long-term field experiments were seen which provide the Chemistry Section with material for its soil studies and work on the nutrition of vegetables. Descriptions were given of the effects of deep and shallow ploughing and of rotavating; of the application of fertilizers and farmyard manure at different depths, rates and times; and of inorganic and organic nitrogenous fertilizers on various rotations of vegetables. A demonstration was given of the restriction in development of the root system of peas brought about by soil compaction following certain cultivation treatments. Results from the use of chromatography in

the study of the biochemistry of vegetables were shown, and this technique is being used in an investigation of a virus inhibitor present in rhubarb sap. A soil map of the Station's 280 acres was on view together with soil monoliths.

The Irrigation Section demonstrated the water-loss by transpiration and evaporation from cauliflowers during bright sunshine and showed that it was equivalent to about 200 gallons an hour per acre of growing crop. Different soil moisture meters were displayed together with data on their performance, and a prototype gauge was shown which indicated the minimum amount of water required to bring soil under a crop to field capacity; this gauge takes into account rainfall and water loss by transpiration and evaporation. The accuracy and efficiency of various techniques for measurement of leaf area were demonstrated, and the effects of different soil moisture conditions on growth, yield and quality of vegetables were shown.

The Entomology Section showed the life-cycle of the cabbage root fly, the damage it causes to brassica crops, and the most effective methods of controlling it. Illustrations were given of some natural predators of the pest and of insecticidal treatments which may destroy the predators, thus leaving a clear field for severe attack by the pest. The biology of the carrot fly, a serious pest of carrots, parsnips and parsley, was shown together with methods of insecticidal control involving seed dressings followed sometimes by supplementary sprays. A tasting panel assesses the degree of taint or off-flavour of carrots which may be brought about by certain insecticidal treatments. The life-history of the pea moth and the pea aphid and their control by DDT were demonstrated. Work in progress on the biology and control of lettuce root aphid was shown; but the recent discovery of varieties resistant to attack appears to offer the best solution of the problem.

The Pathology Section illustrated the life-history of the fungus which causes crook root disease of watercress, and the promising results obtained for the control of the disease by adding to the cress beds material which liberates minute quantities of zinc. It also showed the life-history of the bacterial pathogen found to cause the silvering disease of red beet seed crops, and the degree of control obtained by seed treatment with streptomycin. Methods of eliminating sources of infection by the fungus *Didymella* on outdoor tomato crops, and the effects of fungicides in checking the spread of the disease were exhibited. Parsnip canker has been found not to be invariably associated with damage by carrot fly larvae, and a fungus which can cause the disease has been isolated. Work in progress on virus diseases of rhubarb and watercress was exhibited, also some varieties of mint found to have resistance to mint rust. Results of studies on the control of *Botrytis* in lettuce by cultural methods and by fungicides were also shown.

The Weeds Section demonstrated techniques used in its ecological studies which are providing fundamental information necessary for the development of weed control in vegetable crops by cultural and chemical means. Changes in weed populations brought about by different manurial, cultivation and rotation treatments were described, and the effects of competition between weeds and vegetable crops at different stages of growth were shown. A demonstration was given of the effects of dinoseb (ammonium), dinoseb (amine), and a substituted phenoxybutyric acid MCPB as herbicides for market garden peas, also the degree of tolerance of different varieties to the sprays. The residual pre-emergence herbicide CMU was shown also to be useful for the control of annual weeds in asparagus beds.

The Statistics Section carries out investigations with the object of improving the efficiency of field experiments with vegetables, in addition to its advisory work for other Sections and for outside bodies on the design and analysis of experiments. In studies on the origin of experimental errors in the field, the effects of different methods of sowing peas, and of using different size grades of cauliflower plants when planting in the field were demonstrated. The economics of spacing of glasshouse and frame lettuce were illustrated, and work in progress was shown on the genetics of continuous variation in French beans.

J. Philp

NOCTURNAL TEMPERATURE PROFILE ABOVE BARE SOIL ON CLEAR NIGHTS

It has long been established that in the lowest few hundred feet of the atmosphere there is on calm clear nights on the whole an inversion (that is, temperature increases with height), presumably determined by radiation of heat from the ground. The observations of Johnson and Heywood at Leafield (Meteorological Office Geophysical Memoir 77; 1938) showed that this inversion comes into being remarkably suddenly about sunset. As part of this structure it was supposed that the lowest temperature was normally to be found on the ground surface itself, the air above being cooled by loss of heat to the ground by conduction and convection. Doubts as to whether this was always so have been expressed for a long time. J. Glaisher in 1847 reported that on all clear nights in the year 1843–44 the mean minimum temperature on short grass was 0·8 deg. F. higher than that recorded 1 in. above the top of the grass. Many other workers have found the temperature on radiation nights to be sometimes lower a few inches above the surface than on the surface; but such a structure has not been regarded by meteorologists as a regular feature.

J. V. Lake, of the University of Reading, has recently described in the *Quarterly Journal of the Royal Meteorological Society* (April 1956) the results of temperature observations with the most up-to-date instruments in the lowest few feet over bare soil on calm clear nights. Lake measured temperatures with both minute thermistor beads and with ordinary unscreened alcohol-in-glass minimum thermometers at heights of 0·1, 0·5, 1·5, 2·5, 3·5 and 54 in. The results were all the same: minimum temperature at 2–3 in. above the surface, with an inversion above and a super adiabatic lapse-rate below. For completeness the surface radiation temperature was measured with a spirit thermometer. On the early morning of March 22, 1955, the surface radiation temperature was 21° F. and the temperatures at the higher levels specified above were, in the mean of fifty-two observations at each height, respectively: 18·6, 17·3, 16·6, 16·4, 16·8 and 18·4° F. The standard deviations of the observations were 0·93 deg. F. at 0·1 in. and 0·35–0·46 deg. F. at higher levels.

The temperature profile below the minimum is of the kind which occurs over a surface strongly heated

by sunshine having a lapse-rate more than a thousand times the value of the dry adiabatic lapse-rate (1 deg. F./2,187 in.) and even hundreds of times the so-called 'auto-convective' lapse-rate (1 deg. F./640 in.) at which the density of the air increases upwards. As a by-product of the investigation, it was found that the reduction of surface temperature below the value at sunset was proportional to the square root of the time, in agreement with Brunt's theory of surface-temperature changes on radiation nights, which takes no account of interchange of heat between air and ground and balances radiation loss from the ground against conduction of heat upwards in the soil. The observations were made under dead calm conditions over a level field at a point 100 yards from the nearest boundary, so that vitiation by horizontal influx of colder air seems to be ruled out, and Mr. Lake shows that instrumental errors cannot account for the profiles.

The detailed physical reason for the profile is still obscure. It appears that the air near the ground under calm conditions loses heat by radiation rather than by convection and conduction until a state of radiative equilibrium is reached depending on the water vapour content. The fact that the variation of the surface minimum temperature agreed well with Brunt's theory supports this. It is very desirable, because of the great importance of accurate forecasting of minimum temperatures for agricultural purposes and for general scientific reasons, that an adequate physical theory of the temperature distribution in the lowest foot of the air on radiation nights should be found.

THE CAPERCAILZIE

AN account of the feeding habits and breeding behaviour of the capercailzie has been set out in No. 37 of the Forestry Commission's admirable leaflets. The capercailzie well merited the delightful names by which it was known in medieval times—cock of the woods, horse of the woods, avercalzie, auercalze, wild peacock, wild turkey—for the cock caper is one of the finest game-birds in Europe. In the British Isles, it is found only in the woods and forests of Scotland.

The cock bird is about a yard in length, with the hen capercailzie a foot shorter. Originally, the capercailzie was found in England, Wales and Ireland, as well as Scotland; in England the birds became extinct around 1660–70. In Scotland, the last two positive references to truly native birds seem to be those from the Abernethy and Glenmoriston districts in 1771. The capercailzies present in Scottish woods and forests to-day owe their presence to an introduction of Swedish birds, made in 1837. Then, Lord Breadalbane imported thirteen cocks and nineteen hens and turned them out on his estate at Taymouth Castle, near Aberfeldy, in Perthshire. Unlike previous introductions elsewhere, this one was so successful that after twenty-five years there were more than a thousand birds present on this estate alone.

The typical habitat of the capercailzie consists of hillsides with woods of mature Scots pine. Capercailzie appear to be invading Forestry Commission plantations of Scots pine, larch and spruce when these reach a height of about twenty-five feet.

In winter, the capercailzie's food includes the shoots, buds, leaves, seeds and young cones of the Scots pine, and occasionally those of other conifers. These, however, form only a small proportion of its total food supply, and where only relatively small numbers of capercailzies are found amid middle-aged or maturing pinewoods, little serious economic damage results. The position may be very different in young, newly established plantations, particularly where these lie close to older woods with a heavy stocking of capercailzies. These birds find the winter buds and growing shoots of the young pines very palatable, and all too often they peck out the leading bud, thus causing serious loss of annual growth, and perhaps a distorted stem. Further damage may be done because of the bird's weight; if it settles on a side branch this may break away from the main stem, causing a serious wound to the tree.

Whether or not control measures are necessary depends on local circumstances. In the older woods, the harm the capercailzie does is negligible. Under other conditions, for example, where the felling of mature woods has driven the birds to take refuge in young plantations, it may be necessary to restrict the numbers of the birds in order to avoid serious loss of timber production. Control is commonly effected by shooting, which, owing to the bird's large size and conspicuous appearance, presents no particular difficulties. Provided it does not become unduly numerous in the younger plantations, this interesting and beautiful bird may be tolerated and even encouraged.

FAT FORMATION IN A DIATOM

THE photosynthesis and formation of fats in a diatom, *Navicula pelliculosa*, using carbon-14 as a tracer, has been investigated in some detail by G. E. Fogg (*Ann. Bot.*, N.S. 20, 78, 265; 1956). Fixation into the following cell fractions was determined: (*A*) material soluble in 80 per cent ethanol but insoluble in benzene; (*B*) material soluble both in 80 per cent ethanol and in benzene; (*C*) material insoluble in 80 per cent ethanol. Carbon fixed in photosynthesis was incorporated, rapidly and in amounts representing up to 70 per cent of the total fixation, into fractions *B* and *C*, as well as into fraction *A*. Considerable variation was found in the proportions of carbon entering the three fractions in the light; in actively growing cells the proportion entering fraction *C* preponderated over that in *B*, corresponding to the synthesis of protein, whereas in nitrogen-deficient cells fixation in *B* was the greater, corresponding to the synthesis of fat.

These patterns changed only slowly, over periods of days, following the transfer of cells to altered conditions of nitrate supply. However, when ammonium nitrogen was supplied to nitrogen-deficient cells a marked change in distribution of carbon fixed occurred within 5 min., fixation in fraction *B* falling to a low value and that in *A* rising correspondingly. In cells subjected to prolonged nitrogen-deficiency, fixation in fraction *B* fell to a relatively low value; but the proportion which this fraction formed of the total dry matter in the cells rose as a result of an increased rate of loss from the cells of constituents other than lipides. The distribution of carbon fixed was also dependent on light intensity. Fixation in fractions *B* and *C* rose relatively to that in *A* as light intensity was increased up to 100 foot-candles but fell again at the highest intensity used, 2,000 foot-candles.

ELECTRICAL STIMULATION OF THE HYPOTHALAMUS AND THYROID ACTIVITY

By Prof. G. W. HARRIS, F.R.S., and JAMES W. WOODS

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MUCH interest has been focused on a possible relationship between the central nervous system and the activity of the thyroid gland by the numerous accounts relating psychological trauma with the onset of hyperthyroidism in the human. In recent reports[1,2] the type of individual and the kind of emotional disturbance involved have been described. However, attempts to demonstrate changes in thyroid activity following electrical stimulation of the hypothalamus have not been entirely satisfactory. No increase in oxygen consumption was observed following prolonged stimulation of the hypothalamus; but definite conclusions were not drawn from these data owing to the limitations of the method for measuring metabolic rate in rabbits[3]. Histological signs of increased thyroid activity in rats and rabbits, in which the hypothalamus had been stimulated for four 1-hr. periods on each of two days, have been reported[4].

In the present work the effect of electrical stimulation of the hypothalamus on the thyroid activity of unanæsthetized and unrestrained rabbits has been studied. Electrical stimulation was performed by a modification of the remote-control method previously described[5]. Coils, of about 3,000 turns, were implanted subcutaneously over the lumbar spine and connected by subcutaneous leads to electrodes fixed to the skull vault with dental cement. Stimulation was carried out for periods of 1–7 days, usually 2 days. Changes in thyroid activity were detected by the use of the 'thyroidal ^{131}I release curve'[6]. Following the administration of a single tracer dose of thyroidal ^{131}I this method allows either an increase or decrease in thyroid activity to be observed rapidly and continuously over periods of about 10–14 days. In seven cases the plasma protein-bound or total iodine-131 was measured at intervals throughout an experiment.

Thirty-seven experiments have been performed on twenty-three rabbits in which electrical stimulation (either bipolar or unipolar) has been applied to the pituitary gland (five animals) or some region of the hypothalamus (eighteen animals). These experiments were performed on normal rabbits (twenty-five experiments), after right adrenalectomy (three experiments) and after ovariectomy and right adrenalectomy (nine experiments). In thirty-four experiments either a decrease (twenty cases) or no change (fourteen cases) in thyroid activity was observed. In two experiments (on one normal rabbit) a definite increase in thyroid activity occurred, and in one experiment on another rabbit (after right adrenalectomy) a questionable increase in thyroid activity was seen.

In contrast to the above results are those obtained after removal of the remaining adrenal glands. Up to the present, fourteen of the rabbits described above have been studied after complete adrenalectomy, while being maintained on constant daily doses of cortisone. Electrical stimulation evoked a marked increase in thyroid activity in twenty experiments on ten animals. (Previous to adrenalectomy these ten animals had shown thyroid inhibition in ten experiments and no change in thyroid activity in five experiments.) Ten experiments on the other four animals showed no observable change in such activity on eight occasions, a questionable increase on one occasion and an inhibition on one occasion. The precise localization of the region stimulated in the various animals has not yet been determined, since many of the rabbits are still alive. However, radiographic studies of the animals' heads suggest that it is stimulation of the median eminence of the tuber cinereum which results in increased thyroid activity. During five experiments on four rabbits in which increased thyroid activity was observed from measurements of thyroidal radioiodine, estimations of the plasma radioactivity revealed a marked increase (up to $\times 3\frac{1}{2}$) during the period of stimulation. It is of interest that hypothalamic stimulation could maintain an increased level of thyroid activity even in the presence of a high concentration of thyroid hormone in the blood. Five out of the ten rabbits that showed a clear-cut acceleration of thyroid activity during stimulation eventually died suddenly, and unexpectedly, while being stimulated.

The change of the thyroid response to electrical stimulation of the tuber cinereum after adrenalectomy may be explained in several ways. First, it has been shown that administration of adrenaline may result in inhibition of the thyroid gland in the rabbit[7–9], and it may be argued that stimulation of the hypothalamus in the intact or unilaterally adrenalectomized animal resulted in increased secretion of adrenaline, which in turn prevented any increase in thyroid activity. This explanation seems unlikely, since stimulation of the midline tuber cinereum does not evoke secretion of adrenaline[10], and since the dose of adrenaline necessary to produce prolonged inhibition of the thyroid gland of the rabbit is high[8]. Secondly, administration of adrenocorticotrophic hormone or cortisone has been found to inhibit thyroid activity in the rabbit[11,12]. It is possible that the stimulation of the tuber cinereum caused increased secretion of adrenocorticotrophic hormone by the pituitary gland and that the raised blood-level of adrenal steroids prevented any increase in thyroid activity. Stimulation of the tuber cinereum has been shown to result in pituitary discharge of adrenocorticotrophic hormone[5,13–15], and the dose of cortisone required to reduce thyroid activity in the rabbit is within the physiological range, therefore this explanation seems to be the most likely. The site of action of cortisone in inhibiting thyroid function appears to be the pituitary gland or hypothalamus, since it has been found[12] that cortisone did not modify the thyroid response of the hypophysectomized rabbit to administered thyrotrophic

hormone. It would seem then that electrical stimulation of the tuber cinereum in the normal rabbit excites the liberation of adrenocorticotrophic hormone and thereby increases the concentration of adrenal steroids in the blood, which tends to inhibit the pituitary release of thyrotrophic hormone. In the adrenalectomized animal on constant cortisone maintenance therapy similar stimulation does not result in a sudden rise in blood concentration of adrenal steroids, and consequently an increased discharge of thyrotrophic hormone follows.

These results are of interest in relation to Graves's disease for two reasons: (*a*) as regards the possible role of emotional upsets and the central nervous system in the etiology of the condition[1,2]; (*b*) as regards the high frequency of the condition in patients suffering from Addison's disease[16], and the signs of adrenocortical underactivity (lymphoid hyperplasia, large thymus, lymphocytosis and reduced urinary excretion of 17-keto-steroids)[17–19] and the small adrenal cortex that are present in such cases[20].

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STUDY OF ANTICHOLINESTERASE ACTION IN INSECTS BY A LABELLED POOL TECHNIQUE

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WHEN insects are fed or injected with a suitable compound labelled with a radioactive isotope, a whole range of biochemically related metabolites becomes labelled. The insects can then be killed and extracted in entirety or as some dissected portion under conditions likely to preclude further enzymic or chemical changes. The extracted mixture can be resolved by paper chromatography and the separated labelled metabolites located and determined by scanning the paper chromatogram radiometrically.

This provides what may be described as the spectrum of labelled metabolites which obtained in the living tissues at the instant of death. By comparing the spectra so obtained from control and from poisoned insects, it has been possible to study quantitatively the biochemistry of insecticidal action *in vivo*. Only those compounds undergoing sufficiently rapid turnover will become effectively labelled, but these are the compounds most likely to be important in the minute-to-minute survival of the animal and likely, therefore, to be involved in any acute biochemical lesion. The preparation of the large numbers of radiochromatograms (radioactivities plotted against distance along the paper chromatograms) required by these studies is greatly assisted by automatic radiometric scanning and elution techniques of the kinds described elsewhere[1,2]. These techniques were first used to investigate the effects of insecticides on the phosphorus metabolism of insects[3,4]. By injecting 2-^{14}C-acetate into adult houseflies, they have been successfully extended to non-phosphorus-containing metabolites. Some of the results obtained, particularly in relation to anticholinesterase action in insects, were interesting and, to us, surprising. They may be of comparative significance in vertebrate biochemistry and a preliminary report was thought to be worth while.

2-^{14}C-Acetate was chosen as the initial substrate because of its ubiquitous and central metabolic role. The isotopic methyl carbon seemed less likely to be lost as carbon dioxide as the result of the operation of Krebs's cycle, etc., than the carboxyl carbon. Week-old adult houseflies (*Musca domestica* L.) were injected intrathoracically while under mild *cyclo*propane anæsthesia with 1 µl. of water containing 18 µgm. of 2-^{14}C-sodium acetate equivalent to 2 µc. of carbon-14. Immediately afterwards, 1 µl. of acetone (control) or 1 µl. of acetone containing 10 µgm. of di*iso*propylphosphofluoridate was applied topically to the dorsal surface of the thorax of each fly. The flies were then confined to glass metabolism chambers at 30° C. There was provision for recording automatically and continuously the rate of oxygen consumption by the flies and for the collection, and later chemical and radioassay, of the expired carbon dioxide. After 0·5, 2·0, 5·0 hr., and, in the case of controls only, after 24 hr., groups of twenty flies were removed from the chambers while under mild *cyclo*propane anæsthesia, plunged into liquid nitrogen, rinsed in non-radioactive alcoholic acetate at −10° C., and dissected on a cold slab of solid carbon dioxide.

Heads or thoraces (minus leg and wing appendages) were homogenized in 0·2 *N* sulphuric acid in aqueous ethanol at −10° C., centrifuged at 5° C. and the

Table 1. Effects of Di*iso*propylphosphofluoridate on the Distribution of Soluble Carbon-14 in the Adult Housefly
(per cent total soluble carbon-14)

	0·5 hr.		2 hr.		5 hr.		24 hr.	
	Control	DFP-treated	Control	DFP-treated	Control	DFP-treated	Control	DFP-treated
Head								
Glutamine	8·8	12·4	10·5	7·4	5·9	16·2	8·6	—
Glutamate	21·0	26·4	17·1	16·8	} 55·2	} 50·1	} 47·2	—
Proline + ?	47·4	32·2	48·1	36·4				—
Acetylcholine	0·44	0·80	0·38	0·51	0·48	0·43	—	—
Unknown	22·4	28·2	23·9	38·9	38·4	33·3	44·2	—
	100	100	100	100	100	100	100	
Thorax								
Glutamine	32·0	31·7	31·7	45·0	18·6	45·6	12·0	—
Glutamate	16·3	18·4	12·0	7·6	} 57·4	} 30·0	} 64·0	—
Proline + ?	38·4	34·5	42·7	21·5				—
Acetylcholine	0·19	0·50	0·26	0·23	0·22	0·16	—	—
Unknown	13·1	14·9	13·3	25·7	23·8	24·2	24·0	—
	100	100	100	100	100	100	100	
Acetylcholine by pharmacological assay (μgm. thorax)	0·007	0·025	0·007	0·009	—	—	—	—

clear supernatant poured off. The residue was re-extracted as before and the supernatants pooled. The acid was exactly neutralized with saturated aqueous barium hydroxide and the barium sulphate centrifuged down at a *p*H adjusted to 1·3 with hydrochloric acid. In this way 2-ml. extracts equivalent to twenty heads or thoraces were prepared and stored at −15° C. Aliquots of 20–100 μl. were fractionated paper chromatographically in an aqueous–formic acid–acetone solvent as described for labelled phosphorylated intermediates[3].

Seven distinct ^{14}C-labelled fractions (I to VII), running with mean R_F values of 0, 0·25, 0·47, 0·58, 0·66, 0·75 and 0·91 respectively, were resolved. By co-chromatographic techniques[3], fractions III, V and VI, representing some 75 per cent of the total soluble carbon-14, were identified as free glutamine, free glutamic acid and free proline, together with smaller fractions of other amino-acids. Surprisingly, less than 3 per cent of the thoracic carbon-14 was found as free alanine, and less than 1·5 per cent as free aspartic acid, although these acids are known to occur freely and in high concentrations in insect tissues[5]. They were expected to have become labelled as the result of transaminase reactions with pyruvate and oxalo-acetate as occurs in vertebrate systems[6]. Hydrolysis of the thoracic protein recovered in the insoluble fraction of the original homogenate showed that almost all the protein carbon-14 was present as glutamate and proline only, which suggests that these protein amino-acids were in equilibrium with the free amino-acids. When the fastest running fraction (VII) was reconcentrated[2] and paper chromatographed in aqueous *n*-propanol–formic acid as described for separating choline esters[7], it gave a single major fraction running with an R_F value of 0·8. However, on scanning the paper chromatogram within the sensitive volume of a specially constructed 4-π Geiger–Müller tube[8], a minor fraction, running with an R_F value of 0·47, was readily located and assayed. This labelled fraction and added unlabelled acetylcholine (located with iodine[7]) could never be resolved in acid solvents. The carbon-14 activity was lost in ammoniacal solvents[7]. No detectable fraction of the soluble carbon-14 behaved as free choline, which would almost certainly have been present in the extracts[9]. The proportion of carbon-14 found in the acetylcholine fraction was independent of the weight of unlabelled acetylcholine added at any stage of the fractionation, so that no isotope exchange had occurred between carrier and some other labelled metabolite.

These observations provide independent chemical evidence for the presence of acetylcholine in the thoracic and head tissues of the adult housefly[2,10], the ester here being labelled *in vivo* in the acyl moiety only. The overall carbon-14 spectrum of the control flies did not change drastically over the 24-hr. period studied. Isotopic equilibrium between the soluble metabolites was thus effectively established within 0·5 hr., and the relative carbon-14 contents of the separated fractions were measures of their *relative* chemical concentrations at a particular time. The mean carbon-14 activities recovered in the soluble fractions are shown as a percentage of the total soluble carbon-14 in Table 1. The effects induced by di*iso*propylphosphofluoridate mentioned below were very much larger than the differences in carbon-14 distribution observed in replicate analyses and were obviously significant.

It will be seen that di*iso*propylphosphofluoridate caused an increase in glutamine at the expense of the proline–glutamate fraction, especially after 5 hr. No effects are reported for the 24-hr. exposure because at this time most of the flies treated appeared to be dead and respiration had almost ceased; irrelevant post-mortem effects could not then be excluded. The glutamine accumulation suggests that di*iso*propyl-phosphofluoridate may have rendered necessary an ammonia detoxication mechanism[11]. In a parallel study by the phosphorus-32 labelled pool technique[2], it was shown that topical exposure to di*iso*propyl-phosphofluoridate for 5 hr. had no significant effect on the thoracic levels of adenosine phosphates or other phosphorylated intermediates, and there was no evidence for the formation of inosine phosphates. The ammonia, then, was not derived by deamination of adenine nucleotides. At 5 hr. all the flies appeared to be alive, and while the rate of oxygen uptake was about normal at this time, it was steadily falling after having reached double the control value at 2 hr. Apart from convulsions within minutes of the application of di*iso*propylphosphofluoridate the flies lay motionless until death except for some slight and laboured leg movements. The failure of this substance to exert any detectable effect on the phosphorus metabolism lends no support to a suggestion

that some related phosphorus compounds may exert their insecticidal action in this way[13].

Of interest was the relative rise in acetylcholine in head and thoracic tissues after 0·5 hr., followed by a fall to normal or near normal values after 2 and 5 hr. Since death ensued much later still, it appeared that the expected but temporary accumulation of acetylcholine was not the fatal lesion *per se*, despite the fact that di*iso*propylphosphofluoridate is a potent and relatively irreversible anticholinesterase[13] and has been believed to exert its toxic effect in insects by the same mechanism[14]. The fall in acetylcholine suggested that the esterase inhibition was reversible *in vivo*, or that the choline acetylase system was impaired despite evidence to the contrary[13]. The possibility of alternative pathways of acetylcholine metabolism in insects cannot, of course, be discounted.

By using large aliquots (0·5–1·0 ml.) of the unfractionated thoracic extracts, it was possible to assay the apparent acetylcholine-levels by their action on the rectus abdominis muscle of the frog. The results so obtained by Mr. S. E. Lewis of this Laboratory are given at the foot of Table 1. They confirm the rise and fall found radiochemically. These results suggested a careful investigation of the choline acetylase and acetylcholine esterase-levels in intact insects at different stages of di*iso*propylphosphofluoridate poisoning, the results of which will be reported separately (Lewis, S. E., personal communication). There is some evidence that the level of acetylcholine may fall in vertebrate tissues following an initial rise as the result of anticholinesterase action; but in these cases the inhibition of the acetylcholine esterase was much less likely to be either complete or irreversible[15]. The acute effects of anticholinesterase action in mammals may be largely ascribed to the failure of the neuromusculature of respiration and the consequent anoxia[16]. Therefore, the toxic mechanism was presumably different in these insects, the respiration of which depends largely on diffusion processes[17] and was in any event maintained at a supra-normal level well beyond the time when acetylcholine accumulation was demonstrable. The accumulation of glutamine together with the absence of certain other sustained effects indicate some disturbance in amino-acid metabolism, and this disturbance may have been the fatal lesion in these insects.

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[Jan. 24

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RESOLVING POWER OF GENETIC ANALYSIS

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GENETIC analysis resolves the genome into linkage groups and the linkage groups into loci which can be graphically represented as arranged in a line. Each linkage group has its structural basis in a chromosome and each locus in a small segment of a chromosome. In the case, more unique than rare, of the giant chromosomes of the salivary glands of *Drosophila*, a locus can be identified microscopically with a precision of one band. One band, however, is still a structure of considerable size, more than 1 μ, along the axis of the chromosome.

Though the extraordinary resolving power of genetic analysis, unequalled in biology, was pointed out some years ago[1], the advances made since then render it advisable to restate the questions which it raises. We should do this for two main reasons. One is that this resolving power has increased very considerably, mainly because of the use of micro-organisms, and of selective techniques applied to micro-organisms, for genetic analysis. With some of these techniques the number of products of meiosis which it is feasible to analyse in any one experiment is of the order of 10^6. Recombination fractions of the order of 10^{-6} have already been measured in our laboratory in the mould *Aspergillus nidulans*[2].

The other reason is that we know at present a little more about the chemistry of the chromosomes. We may thus attempt to give a chemical meaning to what genetic analysis resolves, and perhaps even to what is the basis of the process on which genetic analysis is based, that is, crossing-over. In this direction a remarkable paper by Benzer[3] on bacteriophage has already given a lead. In the present paper, Benzer's attempt will be used in a comparative approach.

In the first place, let us see some extreme examples of resolution by means of crossing-over (Table 1). These are all examples of crossing-over between alleles of one gene or, as we prefer to put it, between mutational sites of one 'section' of the linkage map[4]. One section is defined as that part of a chromosome within which recessive mutants behave as allelic of one another, that is, determine a mutant phenotype when in combinations of two in *trans* but not when

Table 1. Examples of Very High Resolution by means of Crossing-over between Alleles in Sections where more than Two Mutational Sites have been Identified

Organism and reference	Mutational sites so far identified No.	Sum of recombination fractions between the two sites found farthest apart (*a*)	Recombination fraction between the two sites found closest together (*b*)	Ratio *a*/*b*
Aspergillus				
bi	3	1×10^{-3}	4×10^{-4}	2·5
ad 8	4	$1{\cdot}8 \times 10^{-3}$	$1{\cdot}2 \times 10^{-5}$	150
Drosophila				
bz	5	3×10^{-4}	3×10^{-5}	10
lz	3	$1{\cdot}5 \times 10^{-3}$	6×10^{-4}	2·5
w	3	5×10^{-4}	8×10^{-6}	62
Phage *T*4				
r II (*A*)	33	$4{\cdot}3 \times 10^{-3}$	$1{\cdot}3 \times 10^{-4}$	330
r II (*B*)	21	$3{\cdot}5 \times 10^{-3}$	1×10^{-4}	35

Refs. 3, 7, 8, 9, 10 and Mackendrick (unpublished)

in *cis* ('Lewis effect'). The examples given are only for cases in which more than two mutational sites are already known, so that at least two intervals have been measured. There are, however, four more examples in *Aspergillus*, not included in the table because in each case only two mutants have been tested against one another, in all of which the recombination rates were of the order of 1×10^{-6}.

If we assume in first approximation that the recombination fraction between two non-adjacent mutational sites is the sum of the recombination fractions in all the intervening intervals, then the values in column (*a*) of Table 1 divided by the values in column (*b*) will give minimal estimates of the possible number of intervals in any section. These estimates, being minimal, have an interest only when they have high values. In the case of *ad* 8 in *Aspergillus*, of *w* in *Drosophila*, and of both *r* II (*A*) and *r* II (*B*) in phage, these values run into several tens or hundreds.

What does this tell us? It tells us that, if the above assumption is not quite invalid, the number of mutational sites within one section of allelism (or gene) separable from one another by crossing-over may run into high numbers. That this is likely to be so can also be deduced from the independent evidence that alleles of one gene originated by different mutational events even if otherwise indistinguishable do usually cross-over with one another, that is, they represent mutation at different sites. Clearly, if the sites at which mutation can occur in one gene are numerous, the chance that two mutants of independent origin involve the same site or group of sites is small[4].

The next step is to consider what part of the total genetic map the smallest recombination fractions so far measured represent. The data are in Table 2. These smallest fractions represent 2×10^{-7}, $2{\cdot}8 \times 10^{-6}$ and 6×10^{-5} of the total map in *Aspergillus*, *Drosophila* and phage, respectively. In other words, we have already resolved the total maps down to fractions of the order of less than one-millionth in some cases, and the available techniques are by no means exhausted. In fact, they could still resolve, without any improvement, linkages one or two orders of magnitude closer. The point is that we cannot at present deduce from first principles where the ultimate limit should be.

Table 2. Smallest Recombinations measured in Three Organisms expressed as a Fraction of the Total Map

	Total map units (*a*)	Minimum recombination so far measured	(*b*)	Ratio b^*/a
Aspergillus	>500	*paba* 1–*paba* 6	1×10^{-6}	2×10^{-7}
Drosophila	280	*waE*–*w*	8×10^{-6}	$2{\cdot}8 \times 10^{-6}$
Phage *T*4	200	*r* II (55)–*r* II (247)	$1{\cdot}3 \times 10^{-4}$	6×10^{-5}

Ref. 3 and Roper (unpublished) and Mackendrick (unpublished).
* *b* here calculated as recombination percentage

The final step is to give chemical meaning to what we are resolving. In this we can follow Benzer's[3] argument, and try to see what happens when we apply it to organisms other than phage. The deoxyribonucleic acid content of a haploid nucleus (or particle) in *Aspergillus* is $0{\cdot}044$ gm. $\times 10^{-12}$ (from the data of Heagy and Roper[5], after correcting an obvious error). In *Drosophila*[6] this content is $0{\cdot}085$ gm. $\times 10^{-12}$ and in phage *T*4 $0{\cdot}0002$ gm. $\times 10^{-12}$. These values correspond to 4×10^7, $7{\cdot}7 \times 10^7$ and 2×10^5 nucleotide pairs in *Aspergillus*, *Drosophila* and phage, respectively. Let us now assume that: (1) all deoxyribonucleic acid constitutes the linear backbone of chromosomes or of phage particles; (2) that crossing-over involves nucleotide linkages; and (3) that the probability of crossing-over is the same at all nucleotides, or repeat of nucleotides. From the data of Table 2 and the values for the nucleotide content just given we can calculate, as Benzer has already done for phage, to how many nucleotide pairs the smallest recombination fractions measured correspond. The number of nucleotide pairs multiplied by the values in the last column of Table 2 gives eight nucleotide pairs for *Aspergillus*, 216 for *Drosophila* and 12 for phage.

These very crude estimates would suggest a few nucleotide pairs as the size of the intervals so far resolved between mutational sites. If the backbone of the chromosome were thought of not as a simple Watson–Crick structure but as a multiple, the number of nucleotide pairs per interval would correspondingly be reduced lengthwise and increased sidewise.

Extending the present reasoning to a whole section of allelism (a gene), it turns out from Table 1 that it could include as a minimum 1,000–8,000 nucleotide pairs in *Aspergillus*, and the same order in *Drosophila* and phage; and we could even speculate further that this is the sort of template required for making a protein.

All these are amusing exercises in numerology. They may even have some heuristic value if they are taken for nothing more than what they are; in particular, if we keep in mind that crossing-over resolves sections held together by bonds, but tells us nothing about what these bonds are and what they hold together. However, there is one solid fact, and this is precisely why we have written this paper. With crossing-over we can analyse the genetic map down to less than one-millionth of it. Even if the total material of the nucleus went into the bonds which we are resolving, we would still have a biological tool of amazing sensitivity, a sensitivity which biochemistry still lacks.

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LETTERS TO THE EDITORS

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Imprinting and the Evolution of Instincts

Dr. R. E. Ewer's communication[1] on this subject calls for some comment. She is concerned with only one of two evolutionary processes. A mode of behaviour may be a learned activity in ancestors, and an unlearned or instinctive one in descendants, *or conversely*. For example, Reyniers[2] reported that newborn rats do not urinate without an external tactile stimulus, but soon 'learn' to do so when their bladders fill. One cannot suppose that no ancestors of the rat urinated without external stimulation. In those bird species so far studied the pattern of song is reported to be learned and unlearned in about equal numbers. Lorenz[3] and Kramer showed that in *Lanius collurio* the practice of spearing insects on thorns was unlearned when nutrition was optimal, but had to be learned when it was deficient. Spalding[4] found that some domestic fowl chicks avoided wasps without learning, others only after being stung. It seems unlikely that the passage from learning to instinct is irreversible.

Dr. Ewer's suggestion as to the evolutionary process by which learned activities are replaced by unlearned is very similar to our own[5,6]. But we doubt[5] whether it is applicable to imprinting, which James[7] described as "the inhibition of instincts by habits". A young nidifugous bird instinctively follows a variety of moving objects. It may get the habit of following only one class of these, for example, ducks or human beings, and it may afterwards perform other activities only on seeing members of this now inappropriate class. Also the development of the usual appropriate adult reactions to members of this class may be inhibited. These reactions and inhibitions are exploited by husbandry. The good shepherd and the good goose-girl lead their flocks, rather than drive them. We think that the word 'imprinting' should be confined to the consequences in *adult* life of infantile experiences. These have not so far been investigated in the recent experiments on following reactions[8–11].

The end results of an imprinting process are remarkably unlike the typical examples of instinctive behaviour, as Lorenz[12] has repeatedly emphasized. An instinctive activity has a somewhat stereotyped motor pattern, and is evoked by a 'releaser' providing 'sign stimuli' which are usually visual or auditory patterns so simple that they can readily be replaced by dummies, that is, these patterns have a simplicity comparable to the patterns of traffic signals designed to make conditioned discrimination easy, and to the patterns which are shown by aposematic animals[13]. Imprinting, in birds at least, seems to be to a *Gestalt*, and many complex activities are directed, and complicated motor adjustments made, to the unusual partner. For example, birds imprinted to human beings often react to both human sexes, and their reactions reveal the many interpretations they put on the variation in human dress[14].

We agree with Dr. Ewer that an instinct is a danger in evolution. An 'innate releasing mechanism' or a 'fixed pattern' of motor activity makes adaptation to new environments *and* to evolutionary changes within the species concerned difficult. Wild poultry kill chicks which do not have the normal colour pattern, and thus make adaptive changes in it impossible except at a very slow rate. Many species have probably become rare or extinct because they could not adapt their behaviour to the changes produced by men. On the other hand, capacities for imprinting do not seem to have been impaired by domestication, which indeed seems to have been built on such capacities[15], even though it might *a priori* have been expected that herding with men and members of other species would have produced selection pressures against a capacity which could lead to incorrect sexual fixation.

Secondly, the capacities which we call learning have been evolved to show a much wider range of variation than morphological characters. Our memories differ among themselves much more than our bodies, and this variation contributes to, rather than detracts from, Darwinian fitness. To paraphrase James in contemporary jargon: an instinct is a behaviour pattern in which developmental homeostasis results in inconspicuous variation both in postnatal development and adult phenotype, whereas a learnt process or lesson involves demonstrable postnatal developmental flexibility[16] and usually results in adaptive variation among the adult phenotypes.

We think that any attempt to apply Waddington's[17,18] technique for what he calls genetic assimilation, so that a learnt response in ancestors is replaced by an unlearnt one in descendants, is only likely to succeed in special circumstances. If the exercise to be learnt is so 'difficult' that it can only be mastered by a small fraction of the ancestral stock, then, by breeding from this minority, in each generation, for many generations, one would hope that the fraction which can learn the task would gradually increase. The question is: Are the developmental processes which we call learning sufficiently like those concerned with wing vein and thoracic development in *Drosophila* for such a selection to result in a fraction of the population performing the task without the environmental stimulus which in the sort of experiment which we are considering would be called the exercise or the experience? Waddington has so far only obtained the genetic assimilation of phenotypes which are the result of gross disruption of the normal canalizations (morphoses). It is probable that the assimilation of 'adaptive hypertrophies' to which learning can be compared[19] would require special selection pressures; for example, adaptedness would have to be made to confer more fitness than adaptability during postnatal life. In Waddington's metaphor, the walls of an entire epigenetic canal would have to be built up higher and steeper.

We are doubtful whether selection for speed of learning which Dr. Ewer suggests would be effective, as this would merely select for animals of what Pavlov called the excitatory or choleric type[20], which can readily learn excitatory reflexes, but not inhibitory ones.

The only example which we know in the literature where selection for a learning ability may be said to have produced a change in the instinctive behaviour of the selected stocks is that recorded by Krechevsky. Tryon had selected 'bright' and 'dull' rats for seven generations. The former learned to find their way through a maze in darkness more rapidly than the latter. Krechevsky[21] found that when confronted with an insoluble problem, in which the correct path was constantly varied, the 'bright' rats chose 'spatial

hypotheses', for example, tried right-hand openings before left-hand. The 'dull' rats tried 'visual hypotheses', for example, dark rather than light openings. What Krechevsky called a hypothesis might be called a type of instinctive behaviour. Krechevsky[22] found that lesions of the striata (visual) area of the cortex reduced the tendency to use visual hypotheses, while lesions of the precentral (motor and somaesthetic) area reduced the tendency to use spatial hypotheses.

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Recruitment and Maturity of the East Anglian Herring

Identification of groups of herring in the southern North Sea by the size of the central zones on their scales, expressed as a proportion of the total length of the fish, l_1, was first applied by Hodgson[1]. We have now used it to confirm that in 1952 the recruits to the East Anglian fishery comprised virtually the whole class of three-year-olds, instead of some of them being delayed to their next year of life. The East Anglian fishery is for mature fish, and this change is unusual; it has been sustained ever since 1952. Our Scottish colleagues have repeatedly told us of younger fish also becoming more important in northern groups of herring[2]. Evidence that had previously caused us to suspect this advancement of maturity is as follows.

In 1950 an increase of the order of 3–5 times in the density of *Calanus* took place on the plankton stations of the Flamborough Line, and in the same year a sharp increase in the average length of three-year-old herring was observed in a number of North Sea fisheries from the Dogger Bank southward. These increases were sustained in subsequent years, and in 1952, when the first-year class enjoying improved feeding conditions throughout all its life appeared in the fishery, the number of three-year-old fish was nearly doubled.

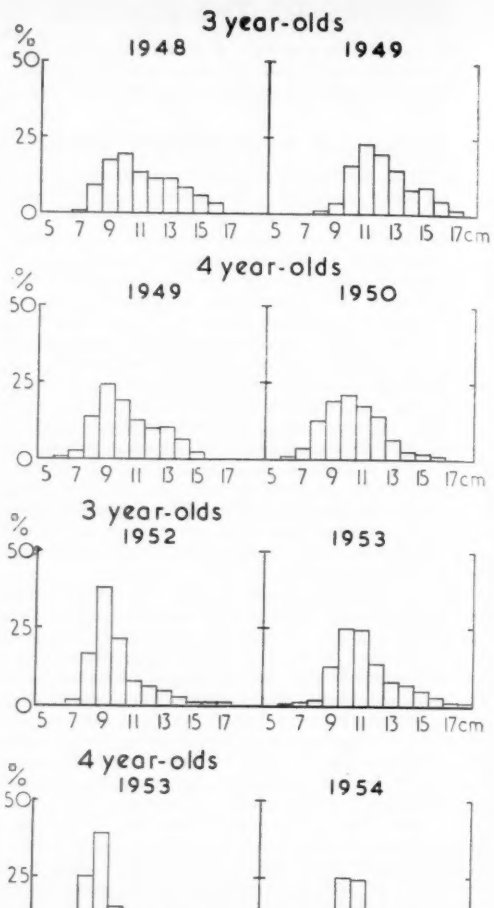

Fig. 1. Distributions of l_1 measurements in the two periods 1948–50 and 1952–54. *a*, Comparison of l_1 distributions of three-year-old fish with that of four-year-olds a year later, in the period 1948–50; *b*, comparison of l_1 distributions of three-year-old fish with that of four-year-olds a year later, in the period 1952–54

The new evidence that full recruitment does take place at three years old is given in Fig. 1. The difference between the l_1 distributions in three-year-olds and that of the subsequent four-year-olds is a well-known phenomenon. Thus, during 1948–50, few small fish with small l_1's reached the fishery as three-year-olds, but came in a year later. The difference is shown clearly in 1949–50 and is discernible, although not so clearly, in 1948–49. During 1952–53 and 1953–54, the l_1 distributions of three-year-olds and the subsequent four-year-olds are almost indistinguishable, and this is more striking in that the difference between the broods is so marked. Thus, after 1952, the first year when the herring would have had better feeding conditions all its life, the l_1 distributions of three-year-olds correspond closely with those of four-year-olds in the following year.

If it is accepted that full recruitment takes place at three years old, it means that the recent changes

in the age distribution of the East Anglian herring fishery are partly attributable to natural causes.

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Protection from Whole-body X-irradiation afforded to Adult Mice by reducing the Body Temperature

It has been shown that the survival-rate after irradiation of new-born rats[1] and mice[2] may be increased by reducing the body temperature to 2–5° C. at irradiation. A slight reduction in sensitivity of adult rats to whole-body irradiation has also been shown[3] by reduction of their body temperature to 18° or 19° C. The development of a technique for inducing hypothermia in rats by Andjus and Smith[4], and recently extended to mice by Goldzweig and Smith[5], has enabled us to demonstrate considerable protection in adult mice irradiated at a body temperature of 0–1° C.

The mice used were male adults of the 'T' strain bred at the National Institute for Medical Research. The *LD*50 (counting survival at 30 days) for normal mice of this strain is approximately 620 r. of X-rays given to the whole body (Fig. 1) based on observations made on 114 mice. All irradiations were done with 190 kV. X-rays, 6 mA., filtered through 1·5 mm. of copper and 1 mm. of aluminium. The cooled mice were irradiated when all heart and respiratory movements had stopped and the colonic temperature was 0–1° C. The revival was started about five minutes after completion of the irradiation and thirty minutes after the animals' body temperature had reached 1°. Doses of 900 r. (14 mice), 1,200 r. (15 mice) and 1,500 r. (7 mice) resulted in 100 per cent survival at thirty days. The mice lost weight during the first ten days after irradiation; but had all regained their original body weight after twenty-two days. Fig. 2 shows the changes in weight of mice irradiated with 900 r. X-rays at a body temperature of 0–1° C. compared with a non-irradiated group whose body temperature was likewise lowered to 0–1° C. and with another group that were given 900 r. X-rays at normal body temperature.

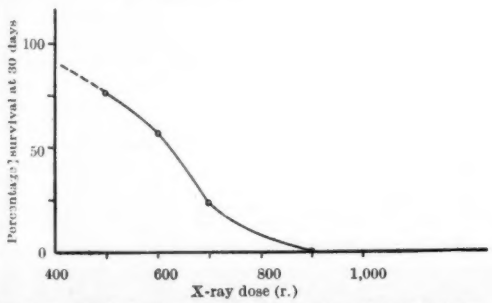

Fig. 1. Survival-rate of 'T' strain male mice after whole-body X-irradiation

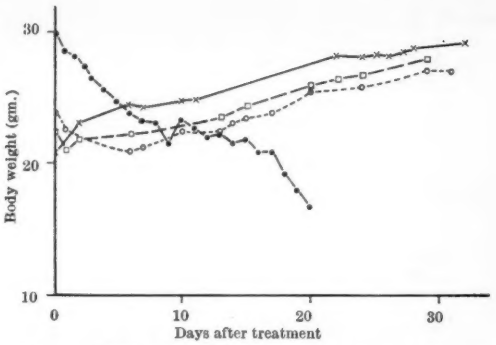

Fig. 2. Weight changes in 'T' strain male mice. ×, Normal controls; □, hypothermic (0–1° C.) controls; ○, 900 r. whole-body X-irradiation during hypothermia (0–1° C.); ●, 900 r. whole-body X-irradiation at normal body temperature

Higher doses of radiation than 1,500 r. at reduced body temperature have not yet been attempted, so the degree of protection given by this treatment has not been established. The dose required to give an *LD*50 at thirty days is, however, clearly more than 2·4 times that required at normal body temperature. The degree of protection is thus greater than that afforded to adult animals by chemical means or by partial anoxia. Nevertheless, since during the lowering of body temperature to 0–1° C. an as yet unknown degree of anoxia, which may be quite severe, is induced, the protection illustrated by these results cannot yet be proportionally assigned to the degree of anoxia on one hand and to the reduced body temperature on the other,

I am indebted to Dr. A. S. Parkes for the supply of the mice, and for facilities in his Division at the National Institute for Medical Research to learn the technique of cooling and reviving animals.

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Ultrasonic Absorption and Thermal Conductivity of Muscle

The chance of survival in severe cold of an individual already comatose and with arrested peripheral blood flow will depend, other things being equal, upon the rate at which heat escapes by conduction through skeletal tissue from the central body region. Fat acts as thermal insulation, and is indispensable to Channel swimmers[1]; but men leading a strenuous life, as in the Armed Services, usually have a thin layer only, and their ultimate tolerance of exposure must depend largely upon the thermal conductivity of their muscle tissue. This is extremely difficult to measure on the living individual; but a large number of tests of excised tissue, human and beef, disclosed a range of variation from more than

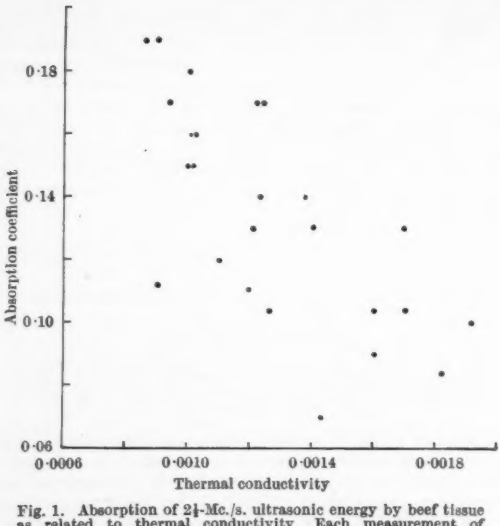

Fig. 1. Absorption of 2½-Mc./s. ultrasonic energy by beef tissue as related to thermal conductivity. Each measurement of absorption is the mean of five points on a piece of tissue 3 in. × 3 in. × 1 in.

double the conductivity of fat (which varies little) down to about the same[2]. If this range is indeed present as between normal living individuals, it would be of practical value to find a method of estimating conductivities on the living, as a help in assessing their suitability for enterprises involving exposure as a hazard.

There are grounds for supposing that the absorption of high-frequency ultrasonic waves by a material such as muscle might vary in the opposite direction to its thermal conductivity. This supposition was tested on fresh beef loin muscle, using a Kelvin and Hughes Mark IV ultrasonic 'flaw detector', which the makers kindly adapted and lent for these experiments. This apparatus causes a quartz-crystal 'probe' to emit every 1/100 sec. a short 2½-Mc. ultrasonic pulse which is received by a second identical probe and displayed on a cathode-ray screen. In the measurement of tissue absorption the probes are set facing one another in a tank of saline, which has negligible absorption. A slab of the tissue to be tested is interposed between the probes, and a fixed voltage (1,000 V.) is applied to the transmitter. The amplitude of the received pulse is adjusted conveniently, and its peak is set to a mark on the screen. The slab of material is then removed, and the voltage reduced to a value giving the same strength of reception. The method serves only for material of closely the same acoustic hardness as the liquid used, otherwise reflexion would occur at the surface of the specimen. This condition is fulfilled very closely for muscle tissue, as is easily verified.

Pieces of freshly killed beef (loin) 3 in. × 3 in. × 1 in. were first tested for absorption at five points; if none departed more than 10 per cent from the mean, the specimen was wiped dry, dipped in oil, and transferred to an apparatus similar to that originally used for conductivity determinations[2,3]. The specimen was in contact on both surfaces with stout copper plates, so that the value for the conductivity was an average of an indefinite character. The results of twenty-five such determinations are shown in Fig. 1, and it is clear that the mean absorption coefficient and the thermal conductivity do in fact vary in inverse ratio for dead excised tissue.

This apparatus will yield reasonable values for the absorption of the calf and thigh muscles of the living individual. It is, however, necessary to develop means for locating precisely the measurements, which vary from centimetre to centimetre, so that an average value can be calculated. This work is in progress.

This investigation is being carried out under consulting contract with the Admiralty (D.R.P.P.). Accommodation for it is provided by St. Bartholomew's Medical School, in Prof. K. J. Franklin's Department, to whom I owe my thanks, also to Dr. O. G. Edholm (Medical Research Council), who supervised the work.

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Stabilization of Xanthine Oxidase Activity by Salicylate

Biological and chemical work with purified xanthine oxidase from cows' milk is handicapped by the loss of its enzymic activity on storage[1,2]. The rate of deterioration, which increases with the degree of purification, is not always the same with different

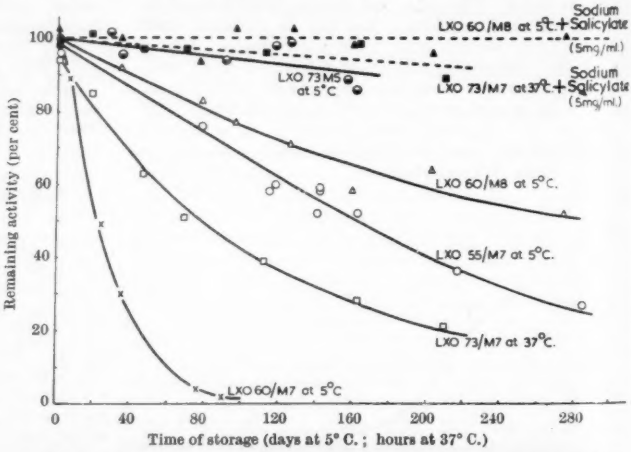

Fig. 1. Xanthine oxidase solutions (see explanation of batch numbers, ref. 10) stored in 1 *M* phosphate buffer, pH 6 (except for *LXO* 60/*M7* and *LXO* 55/*M7*, which were in 0·1 *M* phosphate and 0·2 *M* sodium chloride respectively), at temperatures indicated. Enzyme concentration 0·5–2 per cent. Assays carried out spectrophotometrically (ref. 9)

samples, the cause of such variability being largely unknown so far (Fig. 1).

Stabilization of enzymes could be expected to be brought about by using (*a*) extraneous proteins or polyamides, (*b*) reducing agents, (*c*) chelating compounds and related substances, and (*d*) competitive inhibitors.

While in our case, albumin, polylysine, a di-alkyl analogue of 6.6 nylon (group *a*); glutathione, cysteine, ascorbic acid (group *b*); ethylene diamine tetraacetic acid (versene), 8-hydroxyquinoline sulphonic acid, triethylene tetramine, glyceric acid, glycerine (group *c*) afforded scarcely any significant protection at 37° C. for ten days in *M* phosphate at *p*H 6 (enzyme concentration about 0·5 per cent), sodium salicylate prevented completely any loss of oxidase and dehydrogenase activities[1] at 0–5° C. and almost completely at 37° C. (Fig. 1). Salicylic acid has been reported to act as an inhibitor, though not a very powerful one[5], and our own experiments confirmed that this inhibition was competitive in nature, with $K_i = 1{\cdot}35 \times 10^{-4}\ M$ (spectrophotometric assay at *p*H 8·2, taking $K_s = 5{\cdot}3 \times 10^{-6}\ M$[4]). It is also noteworthy that Keeser[5] reported on 'activation' by sodium salicylate of xanthine oxidase in guinea pig liver after incubation for 2 hr. at 37°; in the light of our findings, this observation may be due to stabilization rather than to activation. Of substances related to salicylic acid (all acids in form of sodium salts), salicylamide, sulphosalicylic acid, salicylaldoxime and gentisic acid showed only slight to moderate effects; but *p*-aminosalicylic acid, acetyl salicylic acid (aspirin) and benzoic acid came near or close to salicylate itself, which remained the best. Our findings may be compared with those of Veitch and McComb[6], who have very recently found a stabilizing effect with *m*-toluic acid on D-amino-acid oxidase.

Salicylate could be removed from the enzyme by dialysis, even after prolonged association. This was proved by the fact that the ratio of ultra-violet absorption at 280 mμ to that at 295 mμ (at which wave-length the salicylate ion has an absorption maximum) returned to the value found with untreated samples, and that $^{14}CO_2H$-labelled salicylic acid was removed almost quantitatively (to about 0·25 mole per mole of total xanthine oxidase) by three consecutive dialysis procedures.

Two points remain to be mentioned: one concerns the low activity established with our xanthine oxidase preparations[1] when using cytochrome-*c* as electron acceptor, which did not increase on adding salicylate, but was inhibited by high concentrations of the reagent; in contrast, 8-hydroxyquinoline augmented this activity slightly, confirming the original observation by Doisy *et al.*[7], who suggested interaction between the iron of the enzyme and the chelating agent. The second point refers to the moderate stabilizing effects of uric acid[8] and 2 : 6-diamino-8-phenyl-purine, the latter a powerful new inhibitor of xanthine oxidase.

Details of these investigations, which include the use of salicylate during the purification process[9], and some evidence for the possible mechanism of loss of activity and stabilization by salicylate will be published elsewhere.

Our thanks are due to Dr. V. C. E. Burnop for the synthesis of labelled salicylic acid, Messrs. D. A. Gilbert and P. G. Avis for the preparation of xanthine oxidase samples, the Research Department of British Nylon Spinners for the nylon analogue, Mr. G. M. Timmis for the purine derivative, and Mrs. K. Tussler for technical assistance.

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Presence of Deoxyribonuclease in Silkworm Polyhedral Virus

Working on the supposition[1,2] that polyhedral virus would be derived from the deoxyribonuclease-controlling gene, I have now been able to demonstrate the presence of a fairly large amount of deoxyribonuclease in polyhedral crystals.

Larvæ of a pure line, *P*44, were injected with a viral solution and polyhedra isolated in the usual way from surviving diseased individuals. Isolation was, however, carried out under cooling conditions and the last sediment washed with 2 *M* sodium chloride, in order to remove remaining cell debris. 5 mgm. of purified polyhedral virus was dissolved in 0·6 ml. of 0·025 *M* sodium carbonate and centrifuged, and the supernatant was carefully neutralized with hydrochloric acid to *p*H 7·5. The enzymic activity of the polyhedral solution was determined viscosimetrically, using spleen deoxyribonucleic acid as substrate. The velocity constant, *k*, of decomposition expressed as a monomolecular reaction at 35° C. was 0·00105. In the determination of deoxyribonuclease, 0·005 *M* magnesium sulphate was added. The polyhedra showed a very feeble nuclease action in the absence of magnesium ions, and it is assumed that they contain almost no activators. Another solution of the same polyhedral virus preparation was then mixed with 0·02 mgm. of crystalline, pancreatic trypsin and kept at 5° C. for 80 min. The *k*-value was raised to 0·00146 by this treatment. In supplementary tests, I observed, however, that the deoxyribonuclease is somewhat inactivated by trypsin at higher temperature. It seems that the nuclease exists at least partly in a special combination with other proteins in the polyhedron. Deoxyribonuclease was also demonstrated in the polyhedra prepared from strain *P*21.

In one control experiment, deoxyribonuclease of digestive organ-free tissues of host larvæ was estimated in a similar manner. It was found that the nuclease activity of a tissue preparation corresponds to only 5 per cent of that of crystalline polyhedral virus.

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Amino-acid Sequence of a Melanophore-stimulating Peptide

A HIGHLY active melanophore-stimulating polypeptide has been isolated from hog posterior pituitary extracts[1]. The amino-acid composition[2] of the active substance (MSH) is consistent with the view that it is an octadecapeptide containing the following amino-acid residues: Arg_1, Asp_2, Glu_2, Gly_2, His_1, Lys_2, Met_1, Phe_1, Pro_3, Ser_1, Try_1, Tyr_1.

In this preliminary communication we wish to report the complete amino-acid sequence of the peptide hormone as deduced from the results of 'stepwise' degradation studies on the intact molecule and from the characterization of peptide fragments isolated from enzymic digests. The methods used in this study may be summarized as follows:

Sequence studies on the intact octadecapeptide. The N-terminal sequence was investigated by a modification[3] of Edman's phenylthiohydantoin method. 2·4 mgm. of the peptide hormone was used for this study, which was carried out as previously described[3,4]. The phenylthiohydantoin derivative of the N-terminal amino-acid was obtained in 85–90 per cent yield and was identified chromatographically as that of aspartic acid. The peptide was afterwards submitted to ten successive applications of the degradation procedure, and the following N-terminal sequence was identified: Asp.Glu.Gly.Pro.Tyr.Lys.Met.Glu.His.(Phe?).

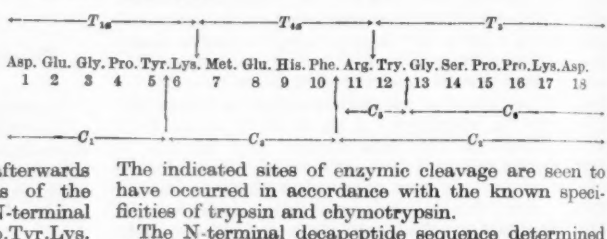
The C-terminal residue was identified as aspartic acid by the carboxypeptidase method[5].

Studies on peptide fragments from enzymic digests

Action of trypsin. The peptide hormone (4·8 mgm.) was treated with trypsin (0·05 mgm.) at *p*H 8·0 and 30° for 30 min. The reaction mixture was submitted to ionophoresis on paper in a pyridine–acetic acid buffer (*p*H 6·5) for 3 hr. at a potential gradient of approximately 40 V./cm., and was resolved into four major and two minor components. The tryptophan and histidine residues were located by means of the Ehrlich and Pauli reagents respectively, and sample portions of each peptide component were separately hydrolysed and analysed for constituent amino-acids by two-dimensional chromatography on paper. The tryptic digest was found to contain the following peptides: T_{1a}, (Asp, Glu, Gly, Lys, Pro, Tyr), T_{1b}, (Asp, Glu, Gly, Pro, Tyr), T_2, (Arg, Asp, Glu_2, Gly, His, Lys, Met, Phe, Pro, Tyr), T_3, (Asp, Gly, Lys, Pro_2, Ser, Try), T_{4a}, (Arg, Glu, His, Met, Phe), T_{4b}, (Arg, Glu, His, Lys, Met, Phe). By the further action of trypsin, T_2 gave equimolar amounts of T_{1a} and T_{4a}, showing that these two peptides are part of the same sequence. T_{1b} and T_{4b} are minor components which, as shown below, are due to chymotrypsin contamination.

Action of chymotrypsin. The hormone (4·8 mgm.) was treated with chymotrypsin (0·05 mgm.) at *p*H 8·0 and 30° for 20 min. The digest was submitted to ionophoresis on paper in a pyridine–acetic acid buffer (*p*H 3·5) for 3 hr. at a potential gradient of 35–40 V./cm.; it was resolved into four major components which were analysed for constituent amino-acids as described above. The chymotryptic digest was found to contain the following peptides: C_1, (Asp, Glu, Gly, Pro, Tyr), C_2, (Arg, Asp, Gly, Lys, Pro_2, Ser, Try), C_3, (Glu, His, Lys, Met, Phe), C_4, (Asp, Glu_2, Gly, His, Lys, Met, Phe, Pro, Tyr). By the further action of chymotrypsin C_4 gave rise to a mixture of C_1 and C_3, indicating that these two peptides belong to the same sequence, and C_2 was split into two new fragments, C_5, (Arg, Try) and C_6, (Asp, Gly, Lys, Pro_2, Ser).

Elucidation of complete amino-acid sequence. Peptides T_{1a}, T_3, T_{4a}, C_1, C_3, C_5 and C_6 were subjected to end-group analysis and sequence studies, from the amino end by means of the Léonis modification[6] of the phenylthiohydantoin method, and from the carboxyl end by means of carboxypeptidase[5]. In this manner the complete structure of each peptide was determined, and the linkages connecting the various fragments ascertained from the overlapping sequences. The complete amino-acid sequence of the melanophore-stimulating hormone is thus established as follows:



The indicated sites of enzymic cleavage are seen to have occurred in accordance with the known specificities of trypsin and chymotrypsin.

The N-terminal decapeptide sequence determined directly on the intact hormone molecule is shown to be in complete agreement with the deduced sequence. Peptides C_1, C_2 and T_3 were also examined by partial acid hydrolysis (12 *N* hydrochloric acid at 37°) and end-group analysis using Sanger's fluorodinitrobenzene reagent[7]. All the di- and tri-peptide fragments which were obtained in this way could be unequivocally located in the indicated sequence.

It may be noted that the sequence Met.Glu.His.Phe.Arg.Try.Gly (positions 7–13) has also been shown to occur in the corticotropins (ACTH, positions 4–10)[8,9]. This observation is of particular interest since it suggests a possible structural basis for the observed intrinsic melanophore-stimulating activity of the corticotropins[8,10], and recalls earlier evidence for the striking relationships between the structure and biological activities of the posterior pituitary hormones oxytocin and vasopressin[11].

Full experimental details of this work will be published elsewhere.

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Bacteria in Experiments on rearing Oyster Larvæ

THE larvæ of many species of marine invertebrates have proved difficult to rear in the laboratory; the proper control of many factors is required, including food, *p*H, temperature and stirring. In particular, considerable attention has been given to the requirements of the larvæ of commercial species of lamellibranchs, especially oysters[1-4]. In such work, which has involved long series of rearing experiments, it has been a common experience of workers (in Great Britain and in the United States) that some batches of larvæ fail to develop properly although the conditions provided have been apparently suitable. Some authors have ascribed this result to either the presence or absence of organic substances in the sea water, implying that such substances are either toxic or essential to the proper development of the larvæ. This view has been supported by the work of Wilson[5] at Plymouth, which has suggested that different natural waters differ in their value as media for developing *Echinus* larvæ.

Observations which I have made suggest that insufficient attention has been given to the possible development of bacteria in rearing experiments and their effect on the larvæ. The purpose of this communication is to direct attention to the very considerable bacterial population which may quickly develop in such experiments. The effect of the presence or absence of the dissolved organic substances may therefore be indirect in that the bacterial population in a larval rearing experiment is very probably dependent on the concentration of the various dissolved organic substances. The concentration of dissolved organic matter in sea water has received comparatively little attention, but it is known to vary considerably[6].

During the summer of 1955, seventeen broods of oyster larvæ were reared under replicate conditions in the laboratory. The experiments were each made in 1 l. of sea water at a temperature of 20° C. Before use, the water was filtered twice through filter candles, the final filtration being through filter candles designed to retain particles more than 1μ in size. The water therefore contained none of the plankton with the exception of a few bacteria. A few ml. of a concentrated *Isochrysis galbana* culture and 300–700 larvæ were added to the water. The additions did not appreciably increase the bacterial population.

The density of the bacteria was observed at intervals in each experiment by plating diluted samples in triplicate using ZoBell's agar medium No. 2216 [7]. The samples were incubated for 48 hr. at 22° C. and the number of developing colonies estimated by counting ten random microscope fields in each plate. An initial peak, varying between 30,000 and 780,000 bacteria per ml., occurred within three or four days of beginning the experiment. In eight of the seventeen experiments it was more than 200,000. After the first five days the numbers usually declined to lower levels and remained roughly stationary at 1,000 to 10,000 per ml. If there was a marked mortality of larvæ, a second peak occasionally occurred. These densities were not sufficient to make the water appreciably turbid.

Six of the seventeen experiments can be classed as successful as they yielded more than ten spat. In five of them the initial peak was less than 200,000 per ml. and in the sixth it was 300,000 per ml. Thus, five of the six successful experiments occurred in the nine experiments where the initial peak was less than 200,000. Only one successful experiment occurred in the eight experiments where the peak was more than 200,000. These experiments suggest, but do not conclusively demonstrate, that, in this case, the bacteria were influencing the successful development of the larvæ. They do, however, clearly show that the bacterial population in such experiments may be considerably in excess of that occurring in the sea, where usually not more than 1,000 per ml. are found[7]. Recent experiments by Oppenheimer[8] show that dense populations of bacteria may occur in laboratory experiments on hatching marine fish eggs. In this case the percentage hatching was improved when the bacterial population was controlled with antibiotics.

It is clear that, in experiments on rearing marine fish and invertebrate larvæ, the bacterial flora cannot be ignored. Differences which have been observed in the value of different natural waters for rearing larvæ may have their origin in the variation in the size of the bacterial flora which the water can support.

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Effect of Superinfection on Phage Sensitivity in Staphylococci

IT has been known for some time that the sensitivity of bacteria to lysis by bacteriophage is conditioned among other things by the presence of lysogenic infection with one or more bacteriophages. Various workers[1-3] have shown that when sensitive cultures were lysogenically infected with typing or even unrelated phages they undergo a change of phage type, the change being a diminution in the number of phages capable of lysing the bacterial cell.

During recent work with staphylococci[4], it was found that one strain could be lysogenically infected and formed a stable system in which every colony was lysogenic; but the culture was not completely immune to the phage in that high titres of phage gave low counts on the lysogenic culture. It is believed that this is due to the presence of a virulent mutant in the phage. The culture employed was N.C.T.C. 8354 with phage N.C.T.C. 8426, the lysogenic system formed being 8354/8426.

Further work was carried out using three other staphylococci, 60, 98 and 105, and three other phages derived from the staphylococci of similar number, that is, 8354 *P* from 8354, 60 *P* from 60 and 105 *P* from 105. These were obtained by filtering the supernatants of overnight broth cultures. The experiments are summarized in Table 1.

It will be seen that when 8354 is rendered lysogenic with 8426 *P* it becomes sensitive to 8354 *P*, 60 *P*

Table 1. Phage Titres per ml. on the Given Indicators

Phage	98	Indicators 8354	8354/8426
8426 *P*	10^{10}	10^{10}	10^{9}
8354 *P*	10^{8}	0	10^{9}
60 *P*	10^{8}	0	10^{9}
105 *P*	10^{8}	0	10^{9}

and 105 *P*. The first-named being its own phage, the problem arose of the stability of the system. It was found that 8354/8426 appeared to contain no 8354 *P* as judged by two methods. First, indicators for 8354 *P* showed no plaques when spotted with the supernatant of 8354/8426. Secondly, the supernatant did not plaque on 8354/8426, which would be expected if any 8354 *P* was present. It appears, therefore, that when 8426 *P* infects 8354 it displaces the prophage of 8354 *P* [5] and as a result 8354 is now sensitive to its own phage and in fact to other phages. This would have the effect of changing the typing pattern of the culture in an unexpected way. This work is being extended by testing other systems made with 8426 *P*.

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Artificial Elimination of the *F* Factor in *Bact. coli* K-12

A few years ago, Lederberg and his co-workers[1,2] found that in *Bact. coli* K-12 there was a difference in sex-compatibility between the two mating cells, one having a transmissible agent, *F*, and the other lacking this agent. Hayes[3] demonstrated that these mating types were very stable heritable characters; but the accidental disappearance of the *F* factor was found by Lederberg *et al.*[1], and by Hayes[4]. The study reported here reveals that it is possible to obtain F^- cells at will from F^+ cells under certain environmental conditions. This phenomenon may be called '*F* elimination'. The environmental factor responsible for *F* elimination is the cobalt or nickel concentration in the medium ($Co(NO_3)_2$, $CoCl_2$, etc.; $Ni(NO_3)_2$, $NiSO_4$, etc.).

The first method of artificial elimination of *F* factor is called the 'citrate method'. A culture of F^+ cells was inoculated into peptone medium (peptone, 10 gm., and glucose, 2 gm., in 1 litre distilled water), and incubated overnight at 37° C. After 24 hr., 0·15 ml. of 0·4 *M* cobalt solution was added to 3 ml. of the culture (the final concentration was 20 m*M*), which was incubated for 24 hr. more. This treated culture was then spread on nutrient agar containing 40 m*M* of sodium citrate, which was used for detoxification of cobalt, and single colonies grown on the medium were isolated at random. By this procedure, it was found that many colonies were converted into F^-. For example, in the mutant K-12 strain 58–161 and the derived strains from 58–161, 10–30 per cent of the colonies were converted into F^-. However, all the F^- were sensitive to cobalt. The frequency of conversion varies according to the strain of K-12 used.

The second method is called 'resistant isolation', in which cobalt-resistant colonies are selected by serial transfer in peptone medium containing cobalt in increasing concentrations. A slow and smooth increase of resistance was observed. Starting from a concentration of 0·5 m*M*, in which strains derived from the original K-12 are able to grow, resistant strains tolerating even 20 m*M* were obtained. These resistant strains were plated on nutrient agar containing 20 m*M* of cobalt, and ten well-grown colonies were isolated at random. In mutant strains 58–161 and Y-40, for example, all ten colonies were F^-, whereas in the W-1485 strain, only four colonies were F^-. However, drug resistance and the F^- character of these strains could be separated; cobalt-sensitive strains derived from the resistant were F^- as before, and cobalt-resistant strains receiving the *F* factor from F^+ bacteria became F^+ themselves.

The mating behaviour of the F^- strains corresponded to that of the F^- strain described by Hayes[5,6] and by Lederberg *et al.*[1]. By the cobalt treatment, other characteristics, for example, nutritional requirements, sugar fermentation, phage-resistance, lysogenicity, indol formation, shape, Gram staining, and antibiotic resistance were not changed. The F^+ trait is very stable in successive serial passages in ordinary media such as broth, peptone and minimal medium. Therefore, in the F^+ clone, the replication of the *F* factor may be closely concerned with bacterial reproduction.

This hereditary conversion of mating type within a clone gives rise to the question of the basis of the change and the mechanism by which the F^- strains occurred. There are two well-recognized possibilities: (*a*) *F* elimination may be due to the selection of spontaneous gene mutation; (*b*) it may be induced by the nickel or cobalt in the medium. From the experimental data, the following may be concluded: (1) *F* elimination occurs even in the absence of cell division (in the first method); (2) the occurrence of *F* elimination is about 100,000 times more frequent than that of other bacterial mutants; (3) F^+ and F^- strains are equally susceptible to the killing action of cobalt or nickel as judged by viable counts, and F^- trait is not linked with cobalt or nickel resistance. These conclusions seem to exclude possibility (*a*). The conjecture used for explaining the contradiction in the stability and instability of the *F* factor is that it is a non-lytic symbiotic agent, as reported by Cavalli *et al.*[2] and Hayes[4]. It may behave as a cytoplasmic factor and/or as extruded state on to the surface of the F^+ cells at a certain stage of its life-cycle. In this state, the sensitivity of the *F* factor to cobalt or nickel may be greater than that of other cytoplasmic factors or of nuclear genes.

I wish to express my appreciation of the suggestions and encouragement given by Prof. H. Kikkawa. I am also indebted to Mr. T. Iijima for his advice and criticism during the course of this study.

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Carotenoids of Some Brazilian Freshwater Gastropods of the Genus *Pomacea*

VERY few reports are available on the carotenoids of freshwater molluscs[1-3]. The early researches of Kruckenberg (1882) and of MacMunn (1883) on the pigments of *Helix pomatia* revealed the presence of a not well-characterized carotenoid and of some chlorophyll in the liver of this snail. Lönnberg studied extensively the pigments of marine molluscs, and Lederer described two new carotenoids in the marine species *Pectunculus glycymeris* and *Pecten maximus*[4,5].

In a short communication on the lipochromes of *Pila glauca*, a South American freshwater species, Comfort reported that the eggs and the 'uterine gland' were bright red in colour and that the pigment could be easily extracted by crushing the material with water[6]. On partition between 90 per cent methanol and petrol ether most of the pigment appeared in the hypophasic fraction. The intact pigment in formol-fixed embryos showed a single spectral band at 550 mμ. However, the pigments were neither separated nor characterized.

More recently, Cheesman isolated the chromoprotein from the eggs of the water snail *Pomacea canaliculata* (Orb.) and was able to study some of its properties. From extensive chromatographic and spectrographic analysis he showed that the pigment resembles astacene from lobster hypodermis but its identity was not definitely established[7].

Having at our disposal several batches of eggs and of living molluscs belonging to the genus *Pomacea* (*Pomacea*, Perry, is the actual name for the genus *Ampullaria* which is very close to *Pila*[8]. We must remark that *Pila* is not found in Brazil and *Pila glauca* belongs to the genus *Pomacea*[9]), it seemed of interest to investigate the distribution and separation of their pigments. *P. haustrum* and *P. dolioides* lay bright red eggs, and the yolk gland shows the same deep colour, whereas in *P. sordida* the colour is orange-yellow and in *P. decussata* light green. These differences in colour seemed to be related to the diet of these snails, since *P. haustrum* and *P. dolioides* are carnivorous–omnivorous and *P. sordida* is mainly herbivorous. The analysis of these biochromes showed also that the carnivorous species presented almost exclusively xanthophyll esters and free xanthophylls and the herbivorous one predominantly carotene.

The separation of the carotenoids was made by the partition test with immiscible solvents. The distribution of the pigments in the epiphase and hypophase after saponification with 10 per cent alcoholic potassium hydroxide solution is given in Table 1.

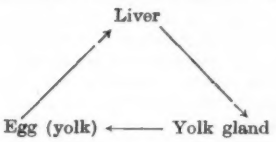
As shown in Table 1, *P. haustrum* and *P. dolioides* contained free xanthophylls and xanthophyll esters and a little carotene. *P. sordida* and *P. decussata* were found to contain only carotene. The epiphasic carotenoids were chromatographed in a magnesium oxide–'Celite' mixture (3 : 1) and the hypophasic in calcium carbonate. Besides β-carotene there has been detected a band corresponding to α-carotene. The hypophasic pigments were shown to be a mixture of three xanthophylls.

Table 1. DISTRIBUTION OF CAROTENOIDS OF SOME SPECIES OF *Pomacea*

Species	Distribution of pigments between 90 per cent methanol and petroleum ether		
	Before saponification	After saponification	Carotenoids characterized
P. haustrum	Mostly epiphasic	Mostly hypophasic	Xanthophyll esters
P. dolioides	Mostly epiphasic	Mostly hypophasic	Xanthophyll esters
P. sordida	Epiphasic	Epiphasic	Carotene
P. decussata	Epiphasic	Epiphasic	Carotene

Purified carotene extract exhibited an absorption maximum at 450 mμ and the predominant hypophasic xanthophyll one at 480–490 mμ. A tentative attempt to modify the carotenoid distribution of the eggs by feeding the herbivorous species a strictly animal diet was unsuccessful. However, the constancy of the carotene in the eggs, liver and yolk gland of these species and the predominance of xanthophyll esters in the carnivores are in accordance with the general rule for other invertebrate animals, that is, that the herbivores store carotene and the carnivores tend to store xanthophylls[3].

The carotenoids existing in the eggs are stored in the liver of the newly hatched young animals, which could be easily shown in the apex of the shell where the liver is located. In the adult female the pigments concentrated in the yolk gland originated probably from the liver. Therefore, the cycle of the carotenoids in these snails may be visualized tentatively as follows:



A study of the distribution and depletion of the liver and yolk gland carotenoids is in progress.

I wish to thank Prof. H. Souza Lopes, of the Department of Zoology, Instituto Oswaldo Cruz, Rio de Janeiro, for the snails used in this work and for help in the dissection and identification of these animals.

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Absence of Keratin in Teleost Epidermis

IT has often been stated that the outermost layers of the teleost epidermis are keratinized[1-4]. Young[5] says that, in the trout, " . . . the squamous epithelium of the epidermis provides the animal with a covering of keratin . . .".

During a study of the epidermal structure of teleosts, the following species of fish were examined: *Salmo salar, S. trutta, Esox lucius, Gadus callarias, G. virens, Molva molva, Onos mustelus, Tinca tinca, Phoxinus phoxinus, Anguilla anguilla, Conger conger,*

Nerophis lumbriciformis, Callionymus lyra, Anarrhichas minor, Trigla gurnardus, Gasterosteus aculeatus, Pleuronectes platessa, Lepadogaster gouanii and *Lophius piscatorius*.

Material was fixed in 10 per cent formalin, Bouin and 70 per cent alcohol, embedded in ester-wax and cut at 10μ. Sections were stained with picrocarmine, Papanicolaou's[6] and Mallory's stain. These do not demonstrate any definite keratinized layer of cells, such as is found in higher vertebrates, although in many of the species examined an outer layer of flattened cells, which stains more darkly in hæmatoxylin and eosin than the rest of the epidermis, sometimes occurs.

A further examination was carried out, using the tetrazolium reaction[7], Chèvremont and Frédéric's method[8] and the DDD method[9]. These give no indication of the presence of sulphydryl groups in the epidermis.

It may be concluded from this work that keratin does not normally occur in the epidermis of the species examined; indeed, it is unlikely, from a consideration of the structure of the epidermis of fish in general, that a keratinized layer is ever found.

If it is the case that the outer layers of the epidermis of all bony fishes never contain keratin, the conclusion must be that this characteristic epidermal structural protein was only developed as a protective layer when the vertebrates began to colonize dry land.

I wish to express my sincere thanks to Prof. P. 'Espinasse, in whose Department this work was done, for his helpful advice.

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Digestion of Nitrogenous Compounds by Ruminants

The utilization of nitrogenous compounds by ruminants is known to be affected by a number of factors peculiar to these animals. Among these, the formation and absorption of ammonia in the rumen have become a subject of considerable interest and importance, as it could perhaps result in a significant wastage of nitrogen in the animal's economy[1–3]. The concentration of ammonia in the rumen can give little indication of the extent of its formation, and, so far as we are aware, no studies have been reported which allow the assessment of just how much of the dietary nitrogen reaches the true stomach under various feeding regimes, and how much is removed at the rumen-level.

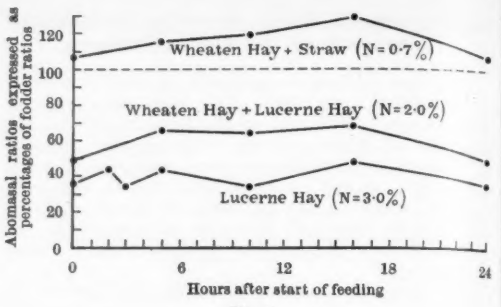

Fig. 1

By using lignin as a marker[4] in the fodder and in the abomasal contents of sheep, we have been able to make such an assessment for a number of diets of widely different protein content. The sheep were fed a regular ration of these diets before being slaughtered at various intervals after feeding. Nitrogen–lignin ratios were determined in the abomasal samples and compared with the ratios in the fodders. For ease of comparison, the ratios in the abomasum can be expressed as percentages of the ratios in the respective fodders. In Fig. 1 the results from three diets are compared in this way. (Details of these and related experiments will be published elsewhere.)

Although relatively few sampling times have as yet been used, the results suggest that they are sufficient to give an approximate measure of the amount of nitrogen reaching the abomasum on each diet. In animals fed on lucerne hay the ratio in the abomasum was maintained at about 40 per cent of the ratio in the fodder, and it must therefore be concluded that the amount of nitrogen reaching the abomasum was equivalent to only 40 per cent of the amount fed. It is to be presumed that much of the remainder was absorbed as ammonia; but it is not known to what extent other soluble nitrogenous compounds were involved. When the ration was a mixture of wheaten hay and lucerne hay, the amount of nitrogen reaching the abomasum was of the order of 60 per cent of the quantity fed.

With the diet of wheaten hay and straw, on the other hand, it appears that more nitrogen reached the abomasum than was present in the fodder. A similar result has been obtained with other low-nitrogen rations of wheaten hay. If the ratio is significantly higher in the abomasum than in the fodder throughout the day the phenomenon may prove to be due to additions of nitrogen to the stomach compartments from the saliva, the blood or the gastric juice. Such additions might be expected to be revealed on feeding low-nitrogen fodders which yield only small amounts of ammonia in the rumen.

Throughout these experiments the ratios have also been determined in the rumen and omasum. The value in the omasum of each sheep was substantially the same as that in the abomasum. So also was the value in the rumen for the greater part of the day; but on diets such as lucerne hay, higher ratios reflected the income of fresh fodder for a short time after feeding.

We consider that extension of this approach may be useful in helping to elucidate some of the many factors which may influence protein digestion in the rumen. For example, we have found that when

starch is added to the lucerne ration, the nitrogen–lignin ratio in the abomasum may be raised. Precise measurements of such effects are needed.

We obtained the samples of abomasal contents from slaughtered animals in order to avoid sampling errors as far as possible. It would no doubt be more satisfactory if animals with fistulæ could be employed so that the individual samples for any one feeding cycle would be derived from the same animal.

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Evidence of a Neuromuscular Block in Tick Paralysis

Tick paralysis, as reviewed by Abbott[1], is a disease affecting man, cattle, sheep and dogs in many parts of the world. Here, in the Pacific north-west, the causative tick is *Dermacentor andersoni* Stiles. The symptoms are characterized by an ascending flaccid paralysis progressing ultimately to bulbar involvement and death due to respiratory failure. It begins after the female tick has been feeding for some days (usually 4–7) and is reversible on the removal of the tick.

The site of the block producing the paralysis was not known. We believe that the following evidence indicates that it is in the myoneural junction.

In Australia experimental work by Ross[2] involving the intrathecal injection of ground-up tick salivary glands seemed to indicate the spinal cord as the possible site of the paralytic process. However, this work has not been confirmed, and there is presumptive clinical evidence against the spinal cord as the site. First, there are no signs of meningeal irritation in the clinical disease and, secondly, in reported analyses of the cerebrospinal fluid not one showed abnormality that we feel could be attributed to tick paralysis.

In May 1954, one of us (Rose, unpublished data) obtained a response by galvanic stimulation of the thigh muscles of a child aged three who was at the time totally paralysed except for the diaphragm. This indicated that the block was situated somewhere in the nerve-muscle mechanism proximal to the muscle fibres.

In 1955 the following studies were made on laboratory animals.

(1) A 40-lb. mongrel dog was infested with thirty pairs of ticks on April 20 and 22. By April 26 paralysis was almost total except for the bulbar region. After a local skin infiltration of procaine, the fibular nerve was exposed. On electrical stimulation there was no muscle response; but the dog whined. This indicated that there was interruption of the motor but not of the sensory path. This was considered a satisfactory preparation; but general anæsthesia under intravenous sodium nembutal seemed preferable.

(2) A 35-lb. lamb was infested with fifty pairs of ticks on April 27. On the evening of May 4 it was in a state of almost total sub-bulbar paralysis; it was able to struggle slightly. Knee and ankle jerks were absent. It was anæsthetized by an intravenous (jugular) injection of 4 c.c. of sodium nembutal. The fibular nerve was again exposed, and electrically stimulated at one-second intervals. No response was obtained at voltages below 150. There was a weak response to voltages of 150 and higher (Fig. 1,*A*).

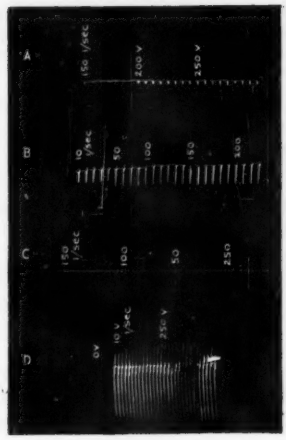

Fig. 1. Kymograph recordings of muscle response to stimulation at one-second intervals of the fibular nerve in paralysed and normal lamb and dog. *A*, Response in partially paralysed lamb at 150, 200 and 250 volts; *B*, response in recovered lamb at 10, 50, 100, 150 and 200 volts; *C*, response in severely paralysed dog at 150, 100, 50 and 250 volts; *D*, response in recovered dog at 0, 10 and 250 volts

All the ticks were then removed from the lamb. It was normal on May 5, when knee and ankle jerks were present and brisk. An identical anæsthetic was then given and the fibular nerve exposed. The tarsal extensor muscles responded strongly to currents as low as 10 volts (Fig. 1,*B*).

(3) A 30-lb. dog was infested with sixty pairs of ticks on May 9. Sub-bulbar paralysis developed by the evening of May 15. Knee and ankle jerks were absent. After anæsthesia with 6 c.c. of intravenous nembutal the fibular nerve was exposed. Stimulation of the nerve with voltages of up to 250 gave no response other than a minute general twitch of the leg (Fig. 1,*C*).

The control test was performed on the same dog, totally recovered, on the evening of May 17. Identical anæsthesia and preparation were used. Full muscle responses to all voltages down to ten were obtained (Fig. 1,*D*).

Although these experiments were limited in number because of the extreme difficulty of paralysing the experimental animals, we consider that they demonstrate the site of the block producing the paralysis as peripheral to the site of stimulation. This, with the previous evidence that muscle paralysed by a tick is capable of response by contraction to direct stimulation, indicates that the site of the block is at the myoneural junction.

A substance producing a neuromuscular block in a manner similar to that caused by curare is apparently involved. Such an interference with a dynamic biochemical process is consistent with the rapid recovery following removal of the tick. To-day many drugs with this action are being investigated and it may be possible by further experimentation to find more specific similarities between these and the substance produced by the tick. We have not found

the paralysis produced by the tick to be lessened by curare antagonists such as prostigmine, and the mode of action, though similar, is probably not identical with that of curare.

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Effect of Environmental Temperatures on the Development of Thermoregulatory Mechanisms in Infant Rats

On the eighteenth day after birth, rats considerably increase their oxygen consumption on exposure to cold[1,2], and their rectal temperature falls at a much slower rate than in younger rats[3]. Hahn, Křeček and Křečková[2], using the method described by Adolph[4], concluded that both chemical and physical thermoregulatory mechanisms develop rapidly between the fourteenth and eighteenth day after birth. Křeček and Martínek[5] demonstrated that in rats raised at 34° C. from birth, thermoregulation develops more slowly, so that on the eighteenth day after birth their rectal temperature falls very rapidly on exposure to cold.

In rats raised at a temperature of 0° C. thermoregulatory mechanisms develop at the same rate as in rats raised at room temperature (20° C.). Their oxygen consumption, however, is increased when measured at 29·5° C. surrounding temperature.

The present communication describes an attempt which has been made to counteract the slowing down of the development of thermoregulatory mechanisms at a high environmental temperature by short exposures to cold.

Rats raised at 34° C. environmental temperature from birth were exposed daily for one hour to 0° C. from the first day after birth up to the eighteenth day. On that day their reaction to cold exposure was studied using the method described by Adolph[4]. Rats were placed in a Bargeton–Krumm-Heller respirometer[6] and their rectal temperature was measured together with their oxygen consumption The thermocouple for measuring rectal temperatures was fixed to the tail and hind legs with adhesive tape. Oxygen consumption and rectal temperature were measured at 29·5° C. for half an hour. Then the surrounding temperature was rapidly lowered to 10° C. and both oxygen consumption and rectal temperature were further measured until the rectal temperature had dropped to 15° C. The time during which rectal temperature dropped to 15° C. after exposure of rats to 10° C. and the oxygen consumption at an environmental temperature of 29·5° C. were taken as indicators. All rats were tested on the eighteenth day after birth.

The rectal temperature of eighteen-day old rats raised at 34° C. and exposed daily for one hour to 0° C. fell at the same rate as in animals raised at room temperature and at a significantly slower rate than in animals raised at 34° C. without interruption (Table 1).

Rats raised at 34° C. and exposed to 0° C. for one hour daily from the fourteenth day up to the eighteenth day, that is, four times altogether, reacted in the same way. Their rectal temperature during the experiment carried out on the eighteenth day after birth dropped at a considerably slower rate than in rats permanently raised at 34° C. The same result was obtained with rats aged eighteen days exposed to 20° C. for one hour daily from birth and otherwise raised at 34° C. (Table 1).

Eighteen-day old rats raised at room temperature up to the fourteenth day after birth and then placed permanently in an environment of 34° C. up to the eighteenth day reacted in the same way as animals raised permanently at 34° C. from birth, that is, their rectal temperature dropped rapidly on exposure to 10° C. during the experimental procedure.

Oxygen consumption measured at a temperature of 29·5° C. during the experiment was significantly higher in rats raised at 0° C. than in all other groups (Table 1).

The large variations in the rate of decrease of rectal temperature are believed to be due to immobilization of the rats during the experimental procedure. The same variations have been observed by other authors[7]. Results indicate that the period between the fourteenth and eighteenth day after birth is decisive for the further development of thermoregulatory mechanisms. This is in agreement with other work[3,8].

It appears that thermoregulatory reactions to cold exposure in rats develop post-natally in close dependence on environmental conditions. The development of adaptation to a certain environmental temperature (0° C., 34° C.) is not identical with the development of thermoregulatory reactions. This is evident from the fact that one hour's exposure to the cold (0° C.) daily suffices to normalize thermoregulatory reactions in eighteen-day old rats raised

Table 1. The Time during which the Rectal Temperature falls to 15° C. after Exposure of Eighteen-day old Rats to an Environmental Temperature of 10° C. and the Oxygen Consumption of the same Rats at 29·5° C. Environmental Temperature before Exposure to Cold

	A	*B**	*C*	*D*	*E*	*F**	*G*
(1) Time (min.)	250 ± 46·5	270 ± 47·0	248 ± 47·8	154 ± 8·3	189 ± 34·2	88 ± 3·8	85 ± 17·7
(2) Oxygen consumption/ml./100 gm./10 min.	48 ± 2·05	64 ± 3·19	44 ± 4·14	38 ± 3·58	47 ± 2·6	46 ± 4·44	38 ± 1·1
No. of animals	8	5	5	5	5	5	5

A, Rats raised at room temperature; *B*, rats raised at 0° C.; *C*, rats raised at 34° C. and exposed to 0° C. for an hour daily for eighteen days; *D*, rats raised at 34° C. and exposed to 0° C. for one hour daily from the fourteenth up to the eighteenth day; *E*, rats raised at 34° C. and exposed to 20° C. for one hour daily for eighteen days; *F*, rats raised at 34° C.; *G*, rats raised at room temperature up to the fourteenth day and at 34° C. from the fourteenth to the eighteenth day.

Differences between *F* and all other groups excepting *G* are significant to $p < 0.01$. The same holds for the differences between *G* and groups *A*, *B*, *C*, *D*. p for group *G* as compared with group *E* < 0·05. This applies to row 1. In row 2 *B* is significantly higher than in all other groups ($p < 0.01$) and *G* is significantly lower than *F*, *C* and *E* ($p < 0.01$ and 0·02).

* Figures taken from ref. 5.

at 34° C. without raising their oxygen consumption at 29·5° C.

Details of this work will be published elsewhere[9].

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Correlation of Total Body Potassium with Body-Water

The total potassium content of the human body[1] is of considerable interest from the point of view of physiology and in connexion with the clinical study of certain muscular disorders. Recently it has acquired additional interest because the radioactivity of naturally occurring potassium-40 in the body constitutes the principal 'background' in some 4π-counters used for the measurement of the gamma contamination of human subjects[2–5]. While it has been known for some time that the total potassium varies considerably around a value of 150 gm. in the average adult male[1,6] and while it has been suspected that fat/muscle ratio is the principal determining factor, the correlation has not been clearly demonstrated.

Using the Los Alamos human counter[2], which permits the determination of total body gamma activity to a precision of 5 per cent in less than 5 min., we have measured more than a hundred subjects with body-weights ranging from 40 to 240 lb. The body-water contents of a selected group of these subjects have been determined by the isotope dilution method using tritium tracer[7,8]. The tritium assay of urine specimens was determined by liquid scintillation counting[9,10]. Fat-free weight was estimated from the body-water using the well-known approximation that body-water is 72 per cent of lean body-weight[11,12].

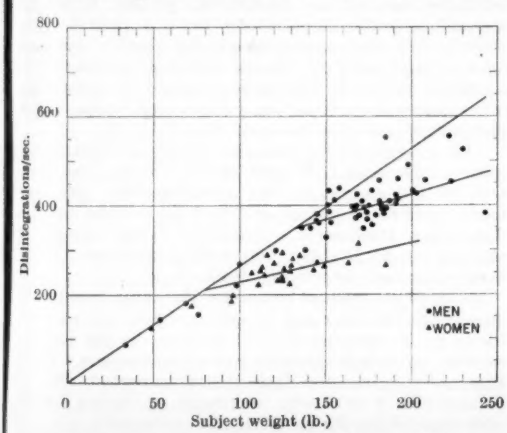

Fig. 1. Natural gamma activity of human subjects

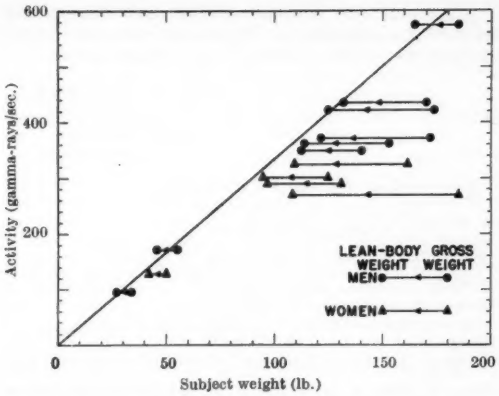

Fig. 2. Natural gamma activity of human subjects in relation to gross and 'fat-free' body-weight

Fig. 1 shows the gamma activity of eighty-one subjects plotted against gross body-weight. The pronounced scatter of the points to the right of a limiting line is clearly evident, as is also the definite separation between male and female subjects. These results indicate that the common practice of expressing total potassium as per cent of gross body-weight[1] will result in a considerable range of values depending on the sex, age, weight, body type and physical activity of the group chosen for measurement.

Fig. 2 shows the results from thirteen selected subjects for which the potassium-40 activity is plotted against estimated fat-free weight as well as against gross weight. (Body-water was not determined on the children; their fat was estimated to be not more than 15 per cent of body-weight.) While some scatter remains, it is obvious that points widely divergent on the original graph are brought close to a common line. This indicates that the amount of fat is the principal factor causing variation in apparent potassium content of the body. (The study of the residual variation is being continued.) The highest natural radioactivity observed is that of a mountain climber (George I. Bell) recently returned from the 1955 Himalayan expedition which attempted Lhotse. At the time of measurement this subject was still below his normal weight as a result of the strenuous activities of the preceding summer.

The determination of body-water should be a valuable adjunct to whole-body counters for normalizing the data to 'fat-free' weight. This will greatly facilitate the evaluation of deviations from the norm resulting from gamma-emitting contaminants or from muscular abnormalities.

The general problem of the *in vivo* determination of gross body composition is an extremely complex one, and the difficulties are clearly defined in the excellent review by Keys and Brozek[11]. The ability of the human counter to determine rapidly and accurately total body potassium, a quantity related to muscle mass, should be of considerable value in the study of this problem.

A more detailed account of these experiments will be published elsewhere. This work was done under the auspices of the Atomic Energy Commission.

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An Inactive Thyroid Gland in *Carassius auratus*

Carassius auratus has been subjected to prolonged artificial selection which has established several unusual features. Among these is the inactivity of the thyroid gland. This gland consists of follicles scattered along the anterior region of the ventral aorta; the follicles are typically inactive, with squamous epithelium and abundant colloid.

The activity of the teleostean gland increases with rising environmental temperature, particularly when nearing the upper limit of the viable range, and is indicated by structural change, which is emphasized by treatment with anti-thyroid drugs. Reaction time of the thyroids of *Phoxinus phoxinus* and *Lebistes reticulatus* varies between two and fourteen days according to the season[1,2]. *Carassius auratus* has a temperature-range of 0–41° C.[3]. Exposure to high environmental temperatures (40° C. for one week; 35° C. for three weeks; 30° C. for five weeks; 25° C. for eight weeks) has no effect on the thyroid structure, and it is not affected by exposure to a low temperature. Immersion in anti-thyroid drugs—0·1 per cent thiourea at 30° C. for five weeks; 0·005 per cent *p*-amino-benzoic acid at 25° C. for three weeks; 0·001 per cent potassium thiocyanate at 25° C. for five weeks—is also ineffective. When the thiocyanate treatment is extended to eight weeks, some glands show marked histological change with increased epithelial height and a reduced amount of colloid, although some remain inactive. Higher concentrations of the drugs prove fatal. The experiments were repeated at intervals throughout the year, so the lack of response cannot be due to a period of seasonal inactivity. Compared with the thyroid of *Phoxinus phoxinus* and *Lebistes reticulatus*, the gland of *Carassius auratus* is unusually inactive.

It has been suggested that the increased thyroid activity at high temperatures is responsible for the limiting of the temperature-range by the upper lethal temperature. It seems probable that the wide temperature-range of *Carassius* is associated with the presence of an inactive thyroid gland.

The inability of the gland to concentrate radio-iodine confirms that it is functionally inactive[4]. The thyroid is reported to be extremely sensitive to thyrotropin[5], which suggests that the latter is normally absent.

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Biting Times of Parous and Nulliparous *Simulium damnosum*

During dissections of the biting fly *Simulium damnosum* in the Sudan in July 1948[1] it was found that the proportion infected with developing *Onchocerca* worms was nearly twice as high in flies caught before 1 p.m. as in those caught later in the day. Many *S. damnosum* were dissected at Farangbaia in the Tonkolili valley, Sierra Leone, in October and November 1955, and it was noticed that, on some days at least, more flies with a plentiful fat-body (indicating that they were nulliparous) were present in afternoon than in morning catches. It thus appeared that nulliparous flies tend to bite largely in the afternoon; but no exact figures were obtained because the amount of fat-body is very variable and does not always clearly differentiate parous and nulliparous flies.

It was found, however, that the appearance of the ovaries and their ducts, when examined in normal saline, would nearly always serve to distinguish the two conditions. In nulliparous flies the oocytes are closely packed in the ovaries and the oviducts are narrow. In parous flies the oocytes, when small (as they nearly always are in caught flies because *S. damnosum* seldom bites when its eggs are developing), tend to be loosely arranged and the oviducts rather broad and wrinkled. The differences in the oviducts cannot be measured, unlike those in anopheline mosquitoes which have a definite ampulla[2]; but they can generally be quickly detected after a little practice. In the few doubtful cases the condition of the fly can be ascertained by examining other features such as the presence or absence of a meconium and the state of the fat-body.

The ovaries of flies caught biting at Farangbaia between December 14 and 29 were next examined. Out of 179 caught in the mornings 60·9 per cent were found to be parous and 12·3 per cent to contain developing *Onchocerca*. Among 202 flies caught in the afternoons 25·2 per cent were parous and 5·9 per cent contained developing *Onchocerca*.

Evidently a person bitten by the same number of flies in the morning and the afternoon would be more likely to be infected with *Onchocerca* in the former, at least in certain localities at certain seasons. When flies are required for dissection to ascertain the infection-rate it is clearly important to choose a suitable time of day for catching. It is desirable to avoid wasting time in dissecting a lot of nulliparous flies

which are unlikely to be infected, and to catch at the same time in different seasons. In the dry season flies may become scarce and difficult to find except in the afternoon. Dissection of flies caught at this time can give a false impression of a seasonal drop in the infection-rate.

It will be interesting to know how general is the tendency of nulliparous flies to bite largely in the afternoon and what is its cause. Perhaps this is linked with the effect, or apparent effect, of physiological condition on the biting times of one or more species of culicine mosquitoes[3–5], biting midges[6] and *Chrysops*[4].

The observations at Farangbaia were part of an entomological survey carried out for the Sierra Leone Development Co., Ltd., and will be reported in detail elsewhere.

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Origin of the Common Wild Oat, *Avena fatua* L.

It is generally considered that differentiation of the hexaploid species of oats has resulted primarily from structural changes and gene mutations involving a small group of chromosomes more or less common to all the species. The different species hybridize readily, giving highly fertile progenies, which indicates considerable homology of the chromosomes of any one species with the others. Indeed, it would be difficult to discover a closer chromosome affinity in any group of polyploids than that indicated by Nishiyama[1] for the four hexaploid oat species *Avena byzantina*, *A. fatua*, *A. sterilis* and *A. sativa*. With complete affinity between any two species represented as 1·000 and no affinity as 0·000, values obtained by Nishiyama from crosses involving the above-mentioned species ranged from 0·983 to 0·998. More recently, however, cytological studies conducted by Joshi and Howard[2] show that meiotic irregularities are found in fairly high frequencies in hybrids with *A. byzantina* as one parent, which implies that at least some of the corresponding chromosomes of the various species are not completely homologous.

According to early literature, and popular belief, *Avena fatua* is considered to be the wild species which has given rise to our cultivated oat *Avena sativa*, and, similarly, *A. sterilis* to the cultivated red oat *A. byzantina*[3,4]. Recently, however, Coffman[5] has advanced the theory that *A. sterilis* is the more likely progenitor of all the hexaploid species, including *A. fatua*, the nature of origin of which he postulates to be on a parallel with that of the frequently appearing fatuoids in the cultivated species. It is presumed to have arisen early in the line of descent from the wild *A. sterilis* and hence possesses more of the so-called 'wild' characters than do fatuoids appearing in cultivated varieties.

Although the occurrence of fatuoids or 'false wild oats' has been noted frequently in the cultivated species and various hypotheses proposed concerning their mode of origin, we are not aware of any reports of their occurrence in *A. sterilis*. As the appearance of such aberrant types in this species would have a direct bearing on Coffman's theory of origin of *A. fatua*, it is thought that the observations reported below will be of interest.

In an experiment designed to study the effects of irradiation on mutation-rates in wild and cultivated species of oats, two lots of seed of *A. sterilis maxima* containing 10 per cent moisture were exposed to X-ray dosages of 20,000 and 30,000 r. units respectively by the senior author when on a visit to the Iowa State College, Iowa, in 1954. The X_1 generation plants produced from the treated seed were harvested separately, and in 1955 forty plants were grown from each for detailed observations of grain characteristics on a single plant basis in the X_2 generation.

Examination of these plants revealed the presence of a number of mutations in both the 20,000-r. and 30,000-r. treated groups, whereas unirradiated seed from the same original stock and grown under the same conditions gave no aberrant forms. The two predominant mutations were changes in grain colour and mode of floret disjunction, and it is with the latter that the present communication is concerned.

The panicle of normal *Avena sterilis maxima* is equilateral with long, drooping branches bearing very few but extremely large spikelets. The spikelets themselves generally comprise 3–5 fully developed florets with only the lowest and second bearing strongly twisted geniculate awns. Separation of the spikelet from the peduncle is by articulation, a well-defined sucker-mouth at the base of the first grain fitting over the top of the callus pad on the peduncle. The upper florets have no such articulation, and in consequence remain fully attached to the first even after shedding. Forcible separation results in irregular fracture of the rachilla at or near its base. A thick tuft of hairs surrounds the sucker of the basal grain of each spikelet and hairs are also present on the rachilla of the second floret.

Out of a total of 227 lines of irradiated material examined, the aberrant type of floret disjunction was observed in 12 lines, in each of which from one to seven such plants occurred. Although the mutant plants were not observed in detail in the field, it was noted in some cases that they were somewhat lacking in vigour and were erect instead of having the characteristic ascending habit of *A. sterilis maxima*. The panicles were smaller with less than ten spikelets, and the overall dimensions of the spikelet parts were 70–80 per cent of the normal.

The most important and characteristic feature of the mutants was in the morphology of the spikelets

Fig. 1. Bases of first and second grains of *A. sterilis maxima* (left) and of first and second grains of mutant (right) showing difference in mode of floret disjunction

themselves. Instead of the usual number there were up to nine florets with, in some cases, as many as the first six having well-filled grain, and all bearing a geniculate awn on the outer pale except the uppermost one or two which bore only a small straight awn. Each floret was articulated with its neighbour by means of a well-developed and readily separated sucker and callus pad (Fig. 1) exactly similar to that found at the base of the first floret in the wild stock. Hairiness, also, was markedly different in these mutants, a tuft of hairs being present on the base of every floret and on each rachilla segment.

The lines producing these fatuoids could be divided into two groups, namely, those in which the mutants were completely sterile and those in which the fertility was as high as in normal *A. sterilis maxima*. No fatuoids of intermediate fertility were found, neither were sterile and fertile forms present in the same line. Differences between the two groups were slight except for a further reduction in vigour and slightly earlier panicle exsertion in the sterile fatuoids.

Apart from the rather high number of florets formed on each spikelet, these fertile fatuoids closely resemble the true *Avena fatua*, and it is suggested that this latter species could well have arisen through a mutation of this type from *Avena sterilis* as indicated by Coffman. This theory is not in conflict with the evidence from phytogeography, since most authors agree that Asia Minor is the centre of origin of oats, and both Vavilov[6] and Malzew[7] state that *A. fatua* and *A. sterilis* are found growing together in that region.

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Spores of the Large Free-living *Amoebae*

In the course of some experiments on *Amoebae* suggested to me by Dr. P. Couillard of Brussels, I have discovered an easy method of procuring clean spores, newly hatching and developing specimens of the large free-living *Amoebae* (*proteus, lescherae, discoides, kerrii*). These stages are difficult to separate from ordinary stock cultures of the *Amoebae*. Hence, I am frequently asked for spores by teachers whose pupils are interested in the life-history of the large *Amoebae*.

The method is as follows:

Use a rather old culture of mixed ages in which fission division is going on in the full-grown adults. Having removed as much as possible of the 'debris', pipette the *Amoebae* into a vessel containing a dilute solution of inorganic salts (potassium chloride, 0·006 gm., magnesium sulphate, 0·002 gm., double super phosphate, 0·007 gm., 1,000 ml. distilled water). (I use Glasgow tap water, which is very soft, instead of distilled water.)

The change in *p*H very quickly kills off the ciliates flagellates and the adult *Amoebae* (often in a beautifully expanded condition).

Allow the whole to stand in a warm place for about a week, then examine the bottom of the Petri dish with a No. 7 water immersion lens. Unhatched and hatching spores, as well as young creeping *Amoebae*, will be seen, the latter feeding on the bacteria produced by the decomposition thus set up.

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Isotopic Exchange of Oxygen between Free Hydroxyl Radicals and Water

We have investigated the exchange reaction[1-4]

$$^{18}OH + H_2{}^{16}O \rightarrow H_2{}^{16}O + {}^{18}OH$$

using potassium ozonide KO_3[5] as a new source of free hydroxyl radicals[6]. Potassium ozonide reacts instantaneously with water enriched in $H_2{}^{18}O$, evolving oxygen according to the reactions:

$$KO_3 + H_2O^* \rightarrow KO^*H + OH + O_2 \quad (1)$$

$$OH + OH \rightarrow H_2O + \tfrac{1}{2}O_2 \quad (2)$$

(and partly $OH + OH \rightarrow H_2O_2$)

$$OH + H_2O^* \rightarrow OH^* + H_2O \quad (3)$$

$$OH^* + OH^* \rightarrow H_2O^* + \tfrac{1}{2}O_2^* \quad (4)$$

The ozonide preparation was of the following composition: KO_3, 89·3 per cent; KOH, 8·4 per cent; H_2O (as $KOH.H_2O$), 2·3 per cent. The experiments, in which water containing 1·38 per cent $H_2{}^{18}O$ was used, were carried out in an apparatus equipped with a magnetic stirrer and the means for introducing the potassium ozonide powder in small portions in an atmosphere of nitrogen. The process of adding the ozonide in all lasted 3–5 min. The degree of enrichment of the evolved oxygen was determined mass-spectrometrically, the error in the oxygen-18 content being less than ± 2 per cent of the measured quantity.

The degree of exchange was referred to the total amount of hydroxyl radicals less the amount utilized in the formation of the hydrogen peroxide, the latter being determined by titration with 0·1 *N* potassium permanganate (molecular oxygen and hydrogen peroxide are incapable of rapid exchange with water[4]). Not more than 15 per cent of the hydroxyl radicals were consumed in the formation of the hydrogen peroxide. Table 1 shows the isotopic composition of the oxygen evolved and the degree of exchange.

It can be seen from the table that at 20° and 0° C. the hydroxyl radicals exchange with water to the amount of about 10 per cent. The degree of exchange does not depend upon the *p*H of the solution; this confirms that the exchange actually occurs between the hydroxyl radicals and the water, and not between the former and hydroxyl ions.

Considering the relatively low degree of exchange, it must be borne in mind that this reaction competes with the extremely rapid reactions of disproportionation and dimerization of the hydroxyl radicals.

Table 1. Isotopic Exchange of Free Hydroxyl Radicals with Water containing 1·38 per cent $H_2{}^{18}O$

Exp.	Weight of KO_3 sample (mgm.)	Initial solution	pH of final solution	Amount of OH formed (in millimoles)	Amount of oxygen evolved ($cm.^3$) (0·760)	Content of oxygen-18 in the evolved oxygen (atm. per cent)	Degree of isotopic exchange (per cent)
				Temperature + 20° C.			
1	217·3	10 $cm.^3$ H_2O^*	13·4	2·23	62·4	0·226	8·9
2	191·3	10 $cm.^3$ H_2O^*	13·3	1·96	56·3	0·226	9·5
6	157·0	35 $cm.^3$ H_2O^*	12·7	1·61	44·3	0·229	11·0
3	161·8	10 $cm.^3$ H_2O^* + 0·17 gm. H_2SO_4 (0·35 *N* H_2SO_4)	0·8	1·66	48·0	0·227	9·8
9	163·5	35 $cm.^3$ H_2O^* + 0·60 gm. H_2SO_4 (0·35 *N* H_2SO_4)	0·5	1·67	46·1	0·226	10·3
							average 9·9 ± 1
12†	134·6	35 $cm.^3$ H_2O	12·7	1·54	41·9	0·204	
				Temperature 0° C.			
7	179·6	35 $cm.^3$ H_2O^*	12·8	1·84	50·0	0·229	10·5
8	155·0	35 $cm.^3$ H_2O^*	12·7	1·59	43·5	0·227	9·8
10	171·1	35 $cm.^3$ H_2O^* + 0·60 gm. H_2SO_4 (0·35 *N* H_2SO_4)	0·5	1·75	47·6	0·231	12·8
11	165·1	35 $cm.^3$ H_2O^* + 0·60 gm. H_2SO_4 (0·35 *N* H_2SO_4)	0·5	1·69	45·3	0·226	10·6
							average 10·9 ± 1

† Exp. 12 served as control, showing that on reaction of potassium ozonide with twice-distilled water the oxygen evolved is of normal isotopic composition.

On the basis of experiments on the decomposition of hydrogen peroxide revealing the absence of rapid exchange between hydroxyl and water, it was concluded[3] that diffusion of this radical during the radiolysis of water takes place according to the normal rather than a Grotthus-type mechanism. Our experiments, on the other hand, indicate a very rapid exchange between the hydroxyl radicals and water. Evidence is thus presented for a Grotthus-type interaction of the free hydroxyl radicals with water.

A full account of this work will be published in due course.

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Thermal and Photochemical Processes in Polystyrene in the Glassy State

Recently, nylon films irradiated with ultra-violet light[1] have been reported to show a post-effect similar in behaviour to one reported earlier in polystyrene films[2]. It is also suggested that the interpretation advanced for the effect in nylon may be applicable to other polymers. In this note, evidence for different mechanisms in polystyrene is discussed. In nylon, the band that develops during both the irradiation and the post-irradiation periods is centred around 2900 A., while in polystyrene the post-irradiation band is centred around 3400 A. The irradiation spectra for the latter indicate no specific absorption in the region investigated but merely a general increase in absorption. The spectra are shown in Fig. 1, where it is seen that the absorption observed after the post-irradiation period is quite different from that observed immediately after the irradiation period.

A more detailed study of the post-irradiation effecs at 340 mμ shows that this increase of absorption it apparently the result of two independent first-order processes occurring simultaneously. Thus, if the absorption due to this thermal process results from the products of two apparent first-order reactions the relation :

$$[R] = \frac{A_\infty - A}{A_\infty - A_0} = \alpha e^{-k_1 t} + \beta e^{-k_2 t}$$

should hold, where α and β are the fractions of the total final absorption produced by the slow and fast reactions, respectively, A is the absorption at time t, A_0 at zero time, and A_∞ is the limiting adsorption. In Fig. 2 the data at 70° C. are shown. The curved line for the overall process is seen to be the sum of the two straight lines on the semi-log plot. Results

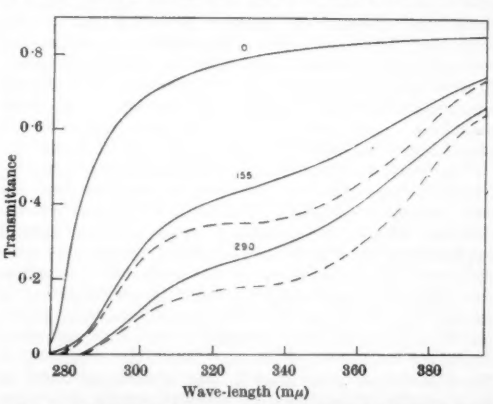

Fig. 1. Effect of radiant energy and subsequent storage on the ultra-violet transmittance of pure polystyrene film. Solid line, exposure for indicated number of hours; dashed line, storage for 290 hr. following indicated exposure time

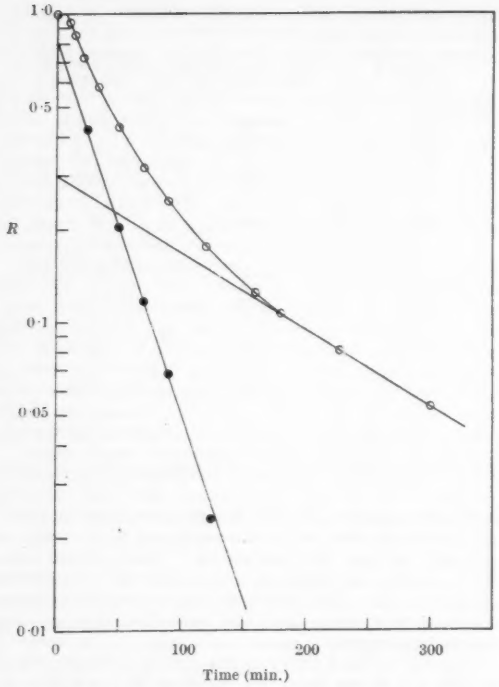

Fig. 2. Semi-log plot of the ratio $[R]$, $(A_\infty - A)/(A_\infty - A_0)$, versus time for the post-irradiation period using polystyrene film at 70° C.

obtained at several temperatures lead to the following expressions for the rate constants : $k_s = 10^{11}\, e^{-22{,}500/RT}$ sec.$^{-1}$; and $k_f = 10^{7}\, e^{-16{,}400/RT}$ sec.$^{-1}$.

The activation energies are not unreasonable for the decomposition of hydroperoxides or for *cis-trans* isomerization processes.

The work of Lutz and Jordan[3] on the photo *trans-cis* and the thermal *cis-trans* isomerization of benzalacetophenone, a structure which may occur in oxidized polystyrene, led to an investigation of this substance in polystyrene film. Preliminary work with this system indicates similar photo and thermal effects with a shift of the maximum absorbance of benzalacetophenone to longer wave-lengths in the solid state. The rate of the thermal *cis-trans* process is considerably slower than that for the post-irradiation reactions in polystyrene. However, it is known that paramagnetic substances catalyse *cis-trans* reactions, and such substances are undoubtedly present in a partially oxidized polystyrene film.

The work of Ford[1] with irradiated nylon films, in which he postulates a "progressive equilibrium" as the general mechanism for such reciprocal photo-thermal effects in polymers, may give a partial explanation for the observed effects in polystyrene. However, this mechanism is not sufficient to explain the difference in absorption-band shape observed in polystyrene as a result of the post-irradiation effect, nor does it explain the character of the post-irradiation reactions as described above. Also, the intensity of the absorption generated in polystyrene at 3400 A. as a result of exposure to radiant energy has been found in this work to be correlated directly with the intensity of absorption bands in the infra-red region ascribed to carbonyl groups[4].

The existence of peroxy radicals in irradiated polymers as suggested by Ford[1] is not entirely compatible with the observation that the activity of γ-irradiated polymethyl methacrylate for initiating polymerization at 29° C. is reduced by exposing the material to air[5]. Exposure to air, however, increases the activity for initiating polymerization at 70° C. These facts are interpreted to mean that exposure to air destroys immobilized free radicals with the formation of hydroperoxides[5].

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March 16.

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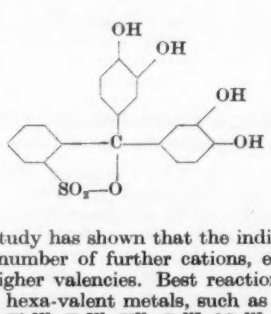
Pyrocatechol Violet as a Detection Reagent for Cations

For the purposes of rapid identification of unknown substances on paper chromatograms, both general reagents reacting with a great number of substances irrespective of their nature, and selective reagents allowing a closer characterization of the particular substance play an important part. The most common detection reagents used in paper chromatography and electrophoresis of inorganic cations, which include hydrogen sulphide, 8-hydroxyquinoline and alizarin, react with a large number of cations. Other commonly used reagents belong to the group of selective agents which react only with a definite and rather small number of substances. Most of these reagents react with elements of various valencies and give no indication on the charge of the cation. In the search for a suitable reagent for the detection of thorium on paper electropherograms[1] use has been made of the detection with pyrocatechol violet, which has recently proved successful as an indicator for complexometric titrations since it forms coloured complexes with some cations, especially Bi^{3+} and Th^{4+} [2]. Pyrocatechol violet is a catechol sulphophthalein with formula :



Further study has shown that the indicator can be used for a number of further cations, especially for metals of higher valencies. Best reaction was noted with tri- to hexa-valent metals, such as Al^{III}, Fe^{III}, Sb^{III}, Bi^{III}, Th^{IV}, Zr^{IV}, V^{V}, Cr^{VI}, Mo^{VI}, W^{VI}, which can be shown on the chromatogram down to 0·1 μgm. Some di- and tri-valent metals react conspicuously enough after approximately ten times greater quant-

ities have been applied. Some higher-valent amphoteric elements with a prevalent non-metallic character, as, for example, arsenic, react only slightly. Monovalent metals do not react with pyrocatechol violet; of the divalent ones alkaline and rare earths and some further cations are also negative. When comparing the sensitivity of this detection reagent with other general reagents as, for example, hydrogen sulphide or alizarin, pyrocatechol violet has been shown to be more sensitive.

The best method of applying pyrocatechol violet (obtainable from Chemapol, Prague II, Czechoslovakia) on chromatograms or electropherograms is in a 0·05 per cent ethanolic solution by immersion. Reaction of individual cations is strongly dependent on *p*H. It is rather advantageous that the slightly acid reaction on paper is optimal since most solvent systems or electrolytes contain hydrochloric or nitric acid and the paper remains acid following the evaporation of the solvent. Under these conditions, blue or purple spots develop against the yellow background. In alkaline medium the colour of some spots takes a greenish hue against the blue background; at this *p*H some divalent cations (cobalt, nickel) can be detected which react only slightly in acid medium.

Thanks are due to Dr. Simon, of the Institute of Analytical Chemistry, Charles University, Prague, for a gift of some rarer compounds.

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Radio Observations of the Planet Venus at a Wave-length of 11 m.

SINCE my first communication on radio signals of 11-m. wave-length from Venus[1], further studies and observations have been made.

Fig. 1 is a record taken May 30, 1956, in which the interferometer lobe pattern due to Venus is very well defined near meridian transit and for an hour or so thereafter. Although better records have been obtained for a few hours, the May 30 record is significant because of the long duration of the Venus signals. Indications due to Venus are discernible from before 11 a.m. E.S.T., when Venus entered the main beam, until nearly 11 p.m. when the signals faded out after Venus set. The wavy line above the chart indicates the lobe pattern of the antenna with the slant lines below showing the positions of the minima. Note that the pattern is shown in rectangular co-ordinates while the actual record is on the more or less slanting co-ordinates of the recorder. The pattern was calculated and checked over much of its extent by the passage of Cygnus *A* through the lobe structure. The minima are not complete nulls since there is a slight unbalance between the two arrays of the interferometer. Ionospheric refraction and scintillation effects are pronounced at 11-m. wave-length. The former effect may be responsible for some variation in the observed positions of the minima, particularly at low angles of elevation. Refraction also presumably accounts for the lag in the time of radio fade-out after the visual setting, this effect being accentuated in the case of Venus because the planet set at an oblique angle with respect to the horizon.

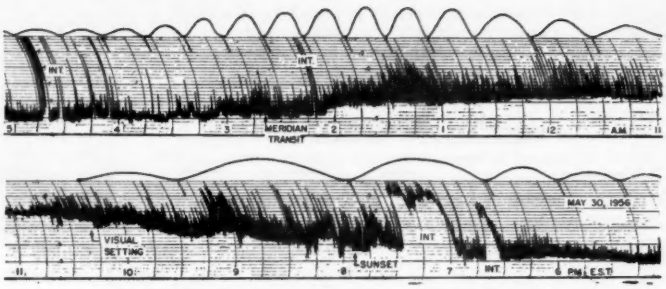

Fig. 1. Record of May 30, 1956, showing the radio noise from Venus obtained with the Ohio State University radio telescope at a wave-length of 11 m. for a period of about 12 hours

Several times on May 30 deflexions were obtained which were presumably interference of some sort (marked *INT*). Some bursts due to local atmospherics were also recorded about noon. However, the minimum in the Venus bursts is readily discernible at 12 noon in spite of this local interference by noting the trend in the shorter spikes in the region. It is to be noted that there are apparently two peaks of activity at about 1.15 and 2.40 p.m. and another pair at about 7.40 and 9.05 p.m., the second pair being 6 h. 25 m. after the first.

It is also to be noted that from 2 to 4 p.m. the base line of the record is elevated in accordance with the lobe pattern, indicating a sufficiently continuous noise to prevent the recorder with its one-quarter second time constant from returning to its normal level. The gradual downward trend in base-level from 11 a.m. to 5 p.m. and upward from 5 to 11 p.m. is due to the galactic background radiation. The small downward jumps in level are presumably due to receiver instabilities.

The Sun was relatively quiet on May 30, and this was the fourth consecutive day on which no important solar flares had been noted. On days of low solar and Venus activity, records are frequently obtained over the entire day which have a recorder pen line that is even narrower and smoother than on the May 30 record at 11 p.m.

Since May 30 further observations have been made, and based on a familiarity with the appearance of the Venus signals it has been possible to go back to the earlier records and recognize that impulsive radio signals from Venus were recorded very probably on at least one occasion in February and with considerable certainty over most of the month of March. No observations were taken during April. As reported earlier, the Venus signals seem to show a peak of intensity at about 90-min. intervals. The March records also show such a peak effect with shorter periods of approximately 20, 39 and 63 min. also in evidence. These periods of more intense activity are plotted as a function of time (E.S.T.) and day of the month in Fig. 2. These observations were made late in the day as the planet passed through the last lobes

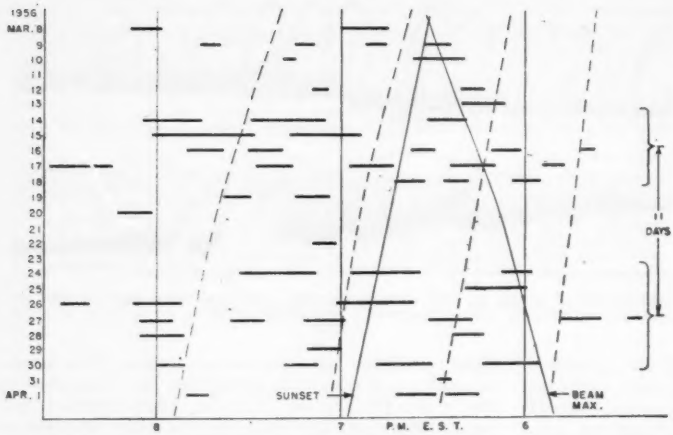

Fig. 2. Periods of peak intensity of radio signals from Venus at 11 m. during March 1956

of the interferometer pattern before setting. These lobes near the horizon are sufficiently wide and the periods of intense Venus signals sufficiently brief for the lobe pattern to have only a minor effect in separating the periods of peak intensity. The lobe minima are shown by dashed lines. The time of sunset and the time when the planet was in the maximum of the antenna primary pattern are also indicated.

The peak periods show a tendency to group around March 16 and 27. Whether this 11-day period is related to the rotation period of the planet is not definite. The peak periods in Fig. 2 also show some tendency to occur progressively earlier during the month. This apparent drift-rate amounts to 5–8 min. per day.

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Observations of Potential Evapo-Transpiration

The Nature Conservancy started at the end of 1955 to measure potential evapo-transpiration using the methods devised by C. W. Thornthwaite and his associates[1]. These studies are continuing; but since the first year's results for Achnagoichan in Rothiemurchus, within the Cairngorms Nature Reserve, are of special topical interest, it is worth referring to them briefly at this stage.

1955 was a particularly dry year; but it was surprising that the figures recorded for potential evapo-transpiration reached as high as 6·8 in. in July and 7·1 in. in August, while even the winter months showed in general more than 1 in. These figures are so much higher than would be given by any of the existing empirical formulæ that they are at once open to suspicion. Investigation of every conceivable source of error has so far yielded none which could account for the whole of the discrepancy, and one is driven to conclude that the formulæ fail to give sufficient weighting to one or more factors. It seems likely that wind was underweighted, and this is borne out by the readings in the present winter months, which were comparatively calm, being significantly less than for the previous winter, which was windy. The effects of wind may be augmented by a föhn effect in the intermontane basin of Mid-Strathspey.

A tentative water-budget, constructed from the evapo-transpiration figures and the rainfall, suggests that 1955 ended with a considerable water deficit, which may not be made up before the 1956 vegetative season is under way; this in spite of a very wet December. The calculations are to a large extent borne out by common observation of stream- and well-levels, wilting of plants, etc., where extremes for the century were recorded. It will be of theoretical, as well as practical, interest to see whether the prognostications of water shortage in 1956 are borne out.

On February 8 this year the Advisory Committee on Weather Control of the United States Senate, in a report to the President, put an end to the doubts about the effectiveness of rain-making by seeding clouds with silver iodide. Its demonstration that precipitation had been increased by amounts between 9 and 17 per cent in the Pacific States becomes well worth pondering in Great Britain, where we are liable to shortages such as experienced in 1955, and which we shall probably not be free from in 1956.

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March 1.

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Capillary Structure of Coals

A conference on the "Ultrafine Structure of Coals and Cokes"[1] was held in London in 1943; later, Bangham *et al.*[2] proposed a model for coals in which the capillary system was located between closely compacted spherical 'micelles'. More recently, in the laboratories of the British Coal Utilisation Research Association, an extensive investigation of the adsorptive properties of some British coals has been carried out, and has led to a new model of the physical structure of coal. This model may be described briefly as follows.

The ultrafine structure consists of an extensive system of cavities interconnected by a maze of narrow capillary-constrictions. These cavities appear to be flat in shape and are two or three times as wide (about 40–60 A.) as the constrictions. The interconnecting constrictions have a bi-modal distribution of widths, with modal values at 10–20 and 15–30 A. for the coals studied—which included an anthracite, a steam coal, a coking coal, and a free-burning coal. This ultrafine structure, which exhibits molecular sieve properties, accommodates about 95 per cent of the total internal surface area, but only about

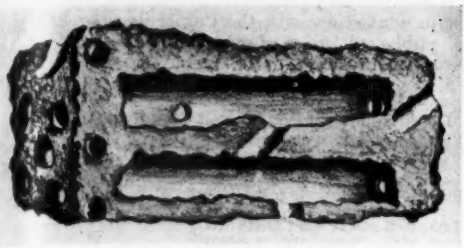

Fig. 1. Model of the constrictions and cavities in coal

50–60 per cent of the total internal free volume of a low rank coal and about 80 per cent of that of a high rank coal. The remainder of the internal free volume is associated with micro-cracks, which are orders of magnitude larger in size. Fig. 1 shows, in model form, this conception of coal structure; the section is taken to show two of the larger cavities (40–60 A. in width) that are reached by molecules permeating the maze of capillaries and constrictions.

The conclusions described above have been obtained from a study of heat of wetting, adsorption and apparent density measurements made with organic adsorbates or dilatometric fluids covering a wide range of molecular configuration, size and chemical properties. The interpretation of these results has required new theoretical treatments to be developed, details of which will be submitted for publication elsewhere.

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Heat-Flow from the Earth at Cambridge

In October 1952 work began on a deep boring at Cambridge under the joint sponsorship of the Geological Survey and the Geology Department of the University. Drilling operations ceased in March 1954 at a depth of 860 ft. 3 in., and the hole, lined with aluminium tubes to 588 ft., was left permanently open. The principal object of this undertaking was to gain further information on the underground geology of the Cambridge region, the Palæozoic succession being of particular interest[1,2]. To this end continuous coring was carried on below 176 ft. 6 in. A preliminary description of the borehole was published in 1953[3]. An outline of the lithology is given at the head of Fig. 1.

The construction of a permanent borehole near the Geophysics Laboratory at Cambridge and the availability of a column of rock from the sub-surface formations provided an opportunity of determining the rate of flow of heat from the Earth. The necessary thermal measurements were made during 1954–55 and the value $(1{\cdot}28 \pm 0{\cdot}12) \times 10^{-6}$ cal. cm.$^{-2}$ sec.$^{-1}$ obtained.

Temperature measurements were made at levels within the borehole 25 ft. apart, the thermometric device used being a thermistor enclosed in a water-tight brass container. The high (negative) temperature coefficient of resistance of these elements makes them particularly suitable for the measurement of small temperature differences. Calibration was carried out against standardized mercury-in-glass thermometers in a series of thermostats and at the ice-point. A specially designed Wheatstone bridge was used for determining the resistance at each level. Twenty-one sets of readings were taken during the ten months following the completion of drilling, and an examination of the results with regard to the transient thermal phenomena associated with borings[4] indicates that the later readings should approximate closely to the equilibrium temperature distribution in the beds penetrated. The temperature-depth curve shown in the diagram has been constructed from values obtained at least six months after the completion of the boring. The ground temperature of 10·22° C. is the mean of daily measurements made in Cambridge between 1911 and 1940. This information was supplied by the Meteorological Office.

Thermal conductivity measurements were carried out in a divided bar apparatus of the type which has become standard in work on rock specimens[5,6]. Determinations were made at sixteen levels in the Palæozoic rocks, each measurement requiring three carefully prepared rock disks of different thicknesses. The results shown in Fig. 1 have been averaged over 25-ft. intervals to correspond with the temperature data. The large fluctuations of thermal conductivity over small vertical distances reflect the inhomogeneity of the Palæozoic rocks. The cores from this part of the borehole contain a wide variety of lithological types and no uniform section more than a few feet in length was recovered. Density and elastic wave velocity measurements were carried out on specimens from closely spaced levels and the results also exhibited a considerable scatter. Seismic refraction experiments and material obtained from other deep borings indicate that the Palæozoic basement of East Anglia is heterogeneous over a wide area[1,2].

The Mesozoic formations penetrated by the borehole consist predominantly of soft clays, and as the water content of the cores had changed considerably by the time the conductivity experiments were made it was decided to base the conductivity distribution in this section on measurements of external samples. The upper part of the Oxford Clay in East Anglia is particularly homogeneous, and a number of vertically oriented samples were collected in newly exposed quarry workings. The thermal conductivities of these specimens were determined immediately. The mean of four measurements was used for the appropriate part of the conductivity–depth curve shown in Fig. 1.

In calculating the heat-flow of $(1{\cdot}28 \pm 0{\cdot}12) \times 10^{-6}$ cal. cm.$^{-2}$ sec.$^{-1}$ only the temperature and thermal conductivity data for the Palæozoic rocks were used. From the mean conductivity of the external samples and the illustrated temperature distribution, a heat-flow of $(1{\cdot}34 \pm 0{\cdot}02) \times 10^{-6}$ cal. cm.$^{-2}$ sec.$^{-1}$ is obtained for the Oxford Clay (179 ft.–338 ft. 2 in.). This is to be regarded as a check on the value quoted earlier.

In 1938 Bullard[7] made thermal measurements in a 100-ft. hole drilled in the Gault near the site of the present boring and deduced a heat-flow of only $0{\cdot}96 \times 10^{-6}$ cal. cm.$^{-2}$ sec.$^{-1}$, which is significantly smaller than the values given above for older formations. Between 138 ft. and 169 ft. 6 in. the

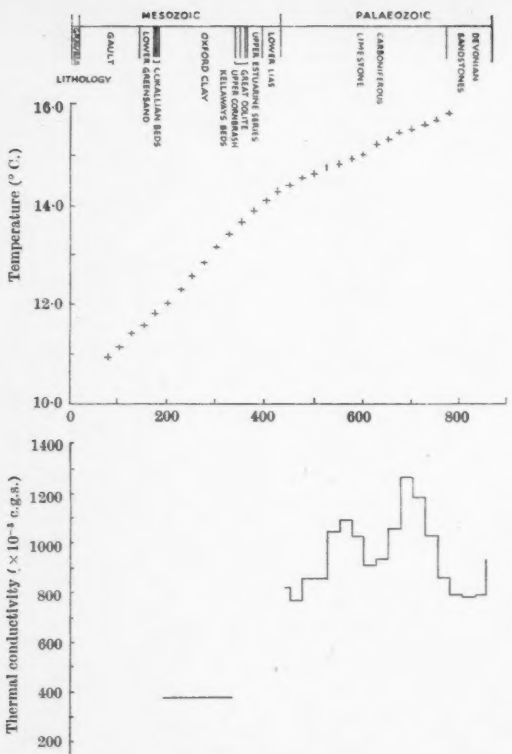

Fig. 1

Cambridge borehole passes through the Lower Greensand, which is the most important source of water supply in the area west of Cambridge. An investigation of water movements in this formation and their possible thermal effects shows that differences in heat-flow between the underlying and overlying beds of the order of magnitude found at Cambridge might be explained by this cause.

Heat-flow measurements near the Earth's surface must be corrected for such effects as climatic changes, igneous activity and rapid denudation in the recent geological past and for topographic inequalities near the point of measurement. Cambridge, however, is situated in a geologically stable area, and the only correction of any importance to be applied is for variations of ground temperature during the past million years or so. Although the Pleistocene glacial deposits of East Anglia have been intensively studied[8] the magnitude of this effect is rather uncertain; but calculations based on Birch's method[9] indicate that the measured heat-flux should be increased by about $0{\cdot}20 \times 10^{-6}$ cal. cm.$^{-2}$ sec.$^{-1}$. This gives an equilibrium heat-flow of $1{\cdot}48 \times 10^{-6}$ cal. cm.$^{-2}$ sec.$^{-1}$ at Cambridge.

Seventeen determinations of the geothermal flux have now been made in Britain in nine different areas, and the mean equilibrium value obtained from them is $1{\cdot}57 \times 10^{-6}$ cal. cm.$^{-2}$ sec.$^{-1}$.

A detailed account of the geophysical work carried out in connexion with the Cambridge borehole is to be published in a forthcoming Bulletin of the Geological Survey.

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Feb. 16.

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Electrical Resistivity of Meteorites

Some attempts have recently been made to interpret the resistivity of the lower part of the Earth's mantle in terms of the semi-conducting properties of silicates[1]. Although it is realized that the mantle may contain a notable proportion of metal phase, as most stony meteorites do, it is generally assumed that the metal phase will occur as isolated grains which will not contribute appreciably to the conductivity.

We have recently measured the resistivity of several stony meteorites containing a variable amount of metal, using a 60-cycle a.c. bridge. Specimens were cut in the shape of square prisms with a cross-section of about 1·7 cm.^{2} and a length of not less than 2·5 cm. (Measurements on shorter specimens gave extremely erratic results; for one specimen about 1·3 cm. long, the conductivities in two directions at right angles varied by a factor of nearly 10^6.) Repeated measurements in the same direction on the same specimen agreed within 10 per cent; but measurements on different specimens cut from the same stone differed in some cases by nearly one order of magnitude. Results are given in Table 1.

These results show that the resistivity of these meteorites departs by several orders of magnitude from that of the silicate phase, which is about 10^2; moreover, the departure is not proportional to the metal-phase content. There is also some evidence, obtained by cutting specimens in different orientations from the same stone, that the material is not isotropic with respect to its resistivity.

If one considers a simple model consisting of parallel silicate and metallic channels with resistivities

Table 1. Resistivity and Average Metallic Cross-section (β) of Stony Meteorites

Meteorite	Metal phase (%)	Specimen length (cm.)	Resistivity (ohm cm.)	β
Kelley	0·1	2·55	5×10^8	
Arriba I*	4·26	2·50	$7{\cdot}9 \times 10^5$	$1{\cdot}3 \times 10^{-11}$
II		2·55	$1{\cdot}2 \times 10^5$	$8{\cdot}2 \times 10^{-11}$
III		8·50	$1{\cdot}8 \times 10^5$	$5{\cdot}5 \times 10^{-11}$
Richardson I	12·15	2·54	$5{\cdot}4 \times 10^6$	$1{\cdot}8 \times 10^{-11}$
II		2·53	$1{\cdot}7 \times 10^6$	$5{\cdot}9 \times 10^{-11}$
Rose City I	17·25	2·50	14·9	$6{\cdot}7 \times 10^{-7}$
II		2·50	6·9	$1{\cdot}4 \times 10^{-6}$
Estacado	31·0	2·61	$7{\cdot}8 \times 10^3$	$1{\cdot}3 \times 10^{-9}$

* Roman numerals refer to different specimens cut from the same stone.

ρ_s and ρ_m, respectively, the ratio β of the average metallic cross-section s_m to the total cross-sections of the sample is easily found to be

$$\beta = \frac{s_m}{s} = \frac{(\rho_s/\rho)-1}{(\rho_s/\rho_m)-1}$$

where ρ is the measured resistivity of the sample. For $\rho_s > \rho > \rho_m$ the formula reduces to $\beta = \rho_m/\rho$. The values of β listed in Table 1 were computed for $\rho_m = 10^{-5}$ ohm cm.

It is interesting to see whether the rapid rise in conductivity at depths between 600 and 900 km. inferred by Lahiri and Price[2] could be explained simply by a slight change in the distribution of the metal phase or in the size of the connecting metallic channels. Let us assume that the resistivity drops from 10^6 ohm cm. at a depth of 600 km. to 10^2 at 900 km., while ρ_s and ρ_m remain constant in this range; let us assume further that $\rho_m = 2 \times 10^{-5}$. Since $\rho_s = (1-\beta)/(1-\beta\rho\rho_m^{-1})$ must be positive, β_{600} must be smaller than 2×10^{-11}, and $\rho_s > 10^6$. Thus ρ and ρ_s are both much larger than ρ_m, and $\beta_{900} \approx \rho_s/\rho = 2 \times 10^{-7}$. Both values of β fall within the range of values listed in Table 1 and are quite possible. We conclude that the change in resistivity could be explained by textural changes and, furthermore, that the electrical properties offer no clue as to the precise metal-phase content at those depths.

In the lower part of the mantle, below 900 km., the average resistivity decreases to a value of about 1 ohm cm.[3]. If we take the resistivity of the metal phase to be about 3×10^{-4}, which is close to the generally accepted value of the resistivity in the core, and if we take $\beta = 10^{-6}$, which is probably an upper limit, we find $\rho \approx \rho_s$. It is thus legitimate to consider that the resistivity of the deep mantle is essentially that of the silicate phase. This seems surprising in view of the results reported in Table 1. The difference in behaviour arises from the fact that the ratio of the metallic conductivity to the silicate conductivity under normal conditions is about 10^{12}; a very small metallic cross-section thus produces a large change in conductivity. In the deep mantle, where the ratio is of the order of 10^8, metallic cross-sections of the order of 10^{-6} produce no appreciable effect. It remains possible, of course, that the metallic cross-section may be larger than this figure. The presence of metallic channels which so largely affect the electrical conductivity under ordinary conditions would have but little effect on the thermal conductivity, as the ratio of the thermal conductivities of the metal and silicates phases is of the order of 10^2–10^3.

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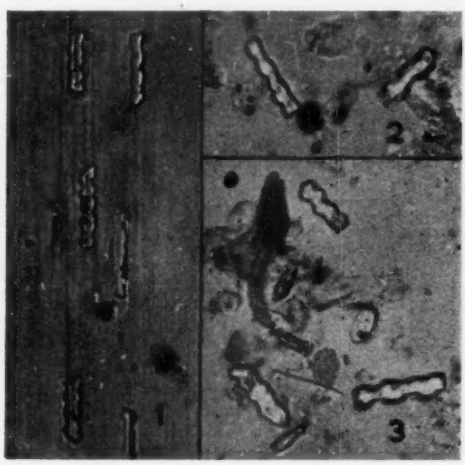
Plant Opal in Soil

In many soils there are small siliceous bodies showing optical isotropy, low refractive index and low density, which identify them with the mineral opal, $SiO_2.nH_2O$ [1]. Some are diatoms or diatom fragments. Others are simple or ornamented rods, tubes, hooks, etc., resembling the opaline bodies which are components of many plants[2–4]. Van Rummelen[5] has figured rods and tubes of isotropic silica from Indonesian soils and has suggested that such particles are always of inorganic origin, being deposited around root hairs which afterwards decay or in soil capillaries. Oosov[6] has observed biologically accumulated silica in Russian soils.

Studies now being carried out in Anglesey on the shapes and sizes of opaline bodies in the soil and in the vegetation leave little doubt that here most of the soil opal has been formed in living plants. An example of the degree of matching is given in the accompanying photomicrographs. Fig. 1 shows opaline bodies in a leaf of *Agrostis tenuis* treated with chromic acid and Figs. 2 and 3 depict objects similar in optical properties, shape and size in the silt fraction from a soil on which this grass forms the major part of the sward. It is not suggested that microscopic examination of these bodies in a soil makes it possible to name the grasses which formed them; but it should permit one to indicate what groups are or have been present. In some places the soil has yielded bodies which match those obtained by the chromic acid treatment of *Equisetum* sp. present on the site. Opaline bodies from grass are abundant in the dung of grazing animals, and many must reach the soil by this means.



Figs. 1–3. Opaline bodies in *Agrostis* leaf and in soil (× 372)

The silt of a swamp deposit normally covered by beach sand in Lligwy Bay, Anglesey (but exposed occasionally, for example, in 1912 and 1953), has yielded an abundance of opaline bodies which are now being investigated.

Frank Smithson

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March 2.

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FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, July 16

British Psychological Society (in the Psychology Department, Birkbeck College, Malet Street, London, W.C.1), at 8 p.m.—Dr. E. Colin Cherry and Mr. B. McA. Sayers: "Some Experiments on the Total Suppression of Stammering"*: Mrs. Pauline M. Marland: "The Shadowing Technique for the Treatment of Stammering—a Progress Report"*.

Thursday, July 19

University of London (at the Institute of Psychiatry, Maudsley Hospital, Denmark Hill, London, S.E.5), at 5 p.m.—Mr. K. A. C. Elliott (U.S.A.): "Metabolism of Human Cerebral Tissues"*.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Senior Research Student in Metallurgy, Engineering (civil, mechanical or electrical) or Chemical Engineering—The Registrar, University College, Singleton Park, Swansea (July 17).

Chief Chemist in the Rivers Pollution Prevention and Fisheries Department—The Chief Inspector, Kent River Board, College Avenue, Maidstone, quoting CC/T (July 20).

Assistant Lecturer in Botany—The Secretary, The University, Exeter (July 21).

Master (preferably young bachelor) to teach Mathematics throughout the school to scholarship level—The Headmaster, West Buckland School, Barnstaple, Devon (July 21).

Research Fellow (chemist or biochemist with research experience in protein or polysaccharide chemistry), to work in collaboration with Dr. D. A. Hall of the Nuffield Gerontological Unit in the Department of Medicine—The Registrar, The University, Leeds 2 (July 27).

Senior Library Assistant (with a degree or professional library qualifications and previous library experience)—The Librarian, University College, Gower Street, London, W.C.1 (July 28).

Assistant Experimental Officer (with a pass degree in chemistry or equivalent, and preferably botanical training) to help with the biochemical study of tuberous *Solanums*—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford, Herts (July 31).

Chief (with an honours degree in agriculture or equivalent, long practical experience in all branches of agricultural science, and considerable experience in research work and administration) of the Agricultural Research Division, Ministry of Agriculture, Sudan Government—The Chargé d'Affaires, Sudan Diplomatic Mission in London, Sudan House, Cleveland Row, St. James's, London, S.W.1, quoting "Chief Research Division 4/439" (July 31).

Lecturer (with experience in grassland husbandry) in Agriculture (Crop Husbandry)—The Secretary, The University, Edinburgh (July 31).

Principal Lecturer (with a first- or second-class honours degree in mathematics, and experience of teaching pure and applied mathematics) in Mathematics at the Royal Naval College, Greenwich—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting Ref. No. 4610/56/1 (July 31).

Principal (qualified to direct a major technical college concerned with full-time and part-time education in engineering to degree standard and other technologies, including postgraduate studies and research)—The Clerk to the Governing Body, Northampton Polytechnic, London, E.C.1 (July 31).

Scientific Officer (with a good honours degree in botany or agricultural botany, and preferably an interest in fruit culture and plant physiology) in the Pomology Department (Ref. POM/2); and a Scientific Officer or Experimental Officer (preferably graduate, with a knowledge of, and an interest in, work on insect pests of soft fruits) in the Entomology Section of the Plant Pathology Department (Ref. PP/2)—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, by Dundee (July 31).

Lecturer in Geology—The Head of the Department of Geology, Imperial College of Science and Technology, South Kensington, London, S.W.7 (August 4).

Assistant (with a degree in science, preferably honours) in the Chemistry Department at Auchincruive, Ayr, for work relating to the spectrographic analysis of agricultural materials—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (August 10).

Dewar Research Fellow in Radiation Chemistry—The Secretary, The University, Edinburgh (August 11).

Professor of Agricultural Botany—The Registrar, The University, Reading (August 20).

Professor of Psychology—The Registrar, The University Reading (August 24).

Senior Lecturer (with experience in research and teaching in one of the following fields: mycology, algology or anatomy) in Botany at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 29).

Chair of Mathematics—The Registrar, University College of North Staffordshire, Keele, Staffs (August 31).

Lecturer in the Ramsay Memorial Laboratory of Chemical Engineering—The Secretary, University College, Gower Street, London, W.C.1 (September 1).

Assistant (preferably with a biological degree and bibliographical experience, and a knowledge of Spanish, Portuguese or Italian) for the preparation of a journal comprising an annual record of the contents of entomological publications—Commonwealth Institute Entomology, 56 Queen's Gate, London, S.W.7.

Chemists (2) (with at least a second-class honours degree and t years postgraduate experience) with the Colonial Insectic Research Unit, Arusha, Tanganyika, to supervise chemical aspe of research into the control of insect pests—The Director of Recru ment, Colonial Office, London, S.W.1, quoting BCD.195/106/06.

Lecturer (Grade II) in Physical Metallurgy—The Registr The University, Birmingham 15.

Lecturer in Engineering, and a Lecturer in Mathematics The President, Mount Allison University, Sackville, New Brunswi Canada.

Lecturer (with a good engineering degree and some experience industry and research) in Mechanical Engineering—The Registr Queen Mary College (University of London), Mile End Road, Lond E.1.

Mycologist, to take charge of the work on plant diseases in relati to crop varieties—The Secretary, National Institute of Agricultu Botany, Huntingdon Road, Cambridge.

Physicist or Engineer (with an appropriate degree), for be research on crop drying and other problems in electro-agricultur Head of the Rural Electrification Department, Electrical Resea Association Field Station, Shinfield Green, Reading.

Senior Lecturer (graduate in physics or chemical engineeri and industrial experience of food processing operations)—The Re trar, National College of Food Technology, Cranwood Street, C Road, London, E.C.1.

Senior Lecturer in Physiology and Pharmacology at Technical College, Bradford—The Director of Education, Town H Bradford.

REPORTS and other PUBLICATION

(not included in the monthly Books Supplement)

Great Britain and Ireland

Flora of Tropical East Africa. Edited by Dr. W. B. Turrill E. Milne-Redhead. Canellaceae. Pp. 4. 1*s*. Caryophyllaceae. Pp. 3*s*. (London: Crown Agents for Oversea Governments and Admi trations, 1956.)

Recommended Practice for Electrical Installations in Caravs Second edition. Pp. iv+18. (London: Institution of Electr Engineers, 1956.) 1*s*. 3*d*.

West of Scotland Agricultural College. Research Bulletin No. Comparison of Production from Six Strains of Perennial Ryegr By I. V. Hunt. Pp. 55. (Glasgow: West of Scotland Agricult College, 1956.) 2*s*.

General Register Office. Studies on Medical and Population Subj No. 9 (in continuation of Study No. 7): General Practitioner's Rec —an Analysis of the Clinical Records of some General Practices du the period April 1952 to March 1954. Pp. vii+80. (London: H Stationery Office, 1956.) 6*s*. 6*d*. net.

International Committee for Bird Preservation: British Sect Annual Report for 1955. Pp. 40+4 plates. (London: Internati Committee for Bird Preservation, c/o British Museum (Natural tory), 1956.) 2*s*. 6*d*.

Association of British Pharmaceutical Industry. Annual Re and Year Book, 1955–56. Pp. 43. (London: Association of Bri Pharmaceutical Industry, 1956.)

Nuclear Power: The Journal of British Nuclear Engineering. Vo No. 1 (May 1956). Pp. 44+xx. Subscription rates: U.K., U.S.A. and Canada, 8 dollars. Single issues, 3*s*. 6*d*. (London: Re Muir Publications, Ltd., 1956.)

Central Office of Information Reference Pamphlet No. 12: He in the United Kingdom Dependencies. Pp. ii+38. (London: H Stationery Office, 1956.) 2*s*. net.

Other Countries

Berichte des Deutschen Wetterdienstes. Nr. 23 (Band 4): Un suchung zur Föhnstatistik des Oberallgäus. Von Eugen Obenl Pp. 40. 4.10 D.marks. Nr. 24 (Band 4): Der Strömungsverlauf s die Erosionsvorgänge und Schneeablagerungen an künstlichen W schirmen nach Untersuchungen im Windkanal. Ein Beitrag Windschutzfrage. Von Wilhelm Kreutz und Wolfgang Walter. Pp 3.20 D.marks. Nr. 25 (Band 4): Untersuchungen über die Sc ausbreitung auf nahe Entfernungen. Von Georg Scheid. Pp. 2.40 D.marks. Nr. 26 (Band 4): Untersuchungen zum Jah gang des mittleren geographischen Höhengradienten der Lufttempe in den verschiedenen Klimagebeiten der Erde. Von Robert B Pp. 42+13 tabellen. Jahresberichte, 1955. Pp. 60. (Bad Kissin Deutschen Wetterdienstes, 1956.)

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